FLUKE

Manual Supplement

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This supplement contains information necessary to ensure the accuracy of the above manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The revision letter stamped on the indicated PCA is equal to or higher than that given with each change.
2. No revision letter is indicated at the beginning of the change.

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Change #1

On page 1-25, Table 1-10, change the 5720A 95% Confidence Level specifications,

FROM:

1.9M	15	16	18	21
10M	28	32	35	40
19M	38	42	45	50

TO:

1.9M	14	16	18	21
10M	27	31	34	40
19M	35	39	42	47

Change #2 - 51438

Rev. K, A6 Wideband Oscillator PCA, Option -03 (5700A-7610)

On page 6-26, Table 6-7,

CHANGE:	Q102,202,302,402,502	TRANSISTOR,SI,NPN,SM SIGNAL,HI	272930	5
TO:	Q102,202,302,402,502	TRANSISTOR,SI,NPN,HI-FREQ,TO-39	912522	5

Change #3 - 52670

Rev. V, A16 Power Amplifier PCA (5700A-7670)

On page 6-66, Table 6-20,

CHANGE:	C12	CAP,CER,2000PF,+-20%,100V,Z5U	757096	1
TO:	C12	CAP,CER,2000PF,+-5%,50V,COG	832618	1

Change #4 - 53000

Rev.U, A13 Oscillator Output PCA (5700A-7651)

On page 6-54, Table 6-16,

CHANGE:	C126,127	CAP,CER,47PF,+-2%,100V,COG	832295	1
TO:	C126,127	CAP,CER,39PF,+-2%,50V,COG	714840	1

On page 7-63, Figure 7-15, change the values of C126 and C127,

FROM : 47 pF
TO: 39 pF

Change #5 - 53101

Rev. K, A17 Regulator/Guard Crossing PCA (5700A-7680)

On page 6-72, Table 6-22,

CHANGE:	CR35	DIODE,SI,SCHOTTKY,40V,DO-34	313247	1
TO:	CR35	DIODE,SI,40PIV,1 AMP, SCHOTTKY	837732	1

Change #6

On page 1-18, change the Maximum load specification,

FROM: .....; 50W output impedance on 220 mV range; all ranges <1000 pF, >25W
TO: .....; 50Ω output impedance on 220 mV range; all ranges <1000 pF, >25Ω

Change #7

On page 1-37, Table 1-22, under 24 hours,

CHANGE: 2 + 100 TO: 0.2 + 100

CHANGE: 15 +500 TO: 0.15 + 500

Under 90 days,

CHANGE : 25 + 100 TO: 2.5 + 100

Change #8

On page 1-27, Table 1-12 replace the column labeled Two-Wire Adder active compensation with the following:

Two-Wire Adder active compensation [Note 4]	
Lead Resistance	
0.1Ω	**1Ω**
±mΩ	
$2+\frac{4\,\mu V}{I_m}$	$4+\frac{4\,\mu V}{I_m}$
$2+\frac{4\,\mu V}{I_m}$	$4+\frac{4\,\mu V}{I_m}$
$2+\frac{4\,\mu V}{I_m}$	$4+\frac{4\,\mu V}{I_m}$
$2+\frac{4\,\mu V}{I_m}$	$4+\frac{4\,\mu V}{I_m}$
$2+\frac{4\,\mu V}{I_m}$	$4+\frac{4\,\mu V}{I_m}$
$2+\frac{4\,\mu V}{I_m}$	$4+\frac{4\,\mu V}{I_m}$
$2+\frac{4\,\mu V}{I_m}$	$4+\frac{4\,\mu V}{I_m}$
10	15
10	15
50	60
100	120
I_m= Current Produced by Ohmmeter	

5700A/5720A

Series II Multi-Function Calibrator

Service Manual

PN 601630
June 1996
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5/94

Interference Information

This equipment generates and uses radio frequency energy and if not installed and used in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation.

Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

There is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of more of the following measures:

- Reorient the receiving antenna
- Relocate the equipment with respect to the receiver
- Move the equipment away from the receiver
- Plug the equipment into a different outlet so that the computer and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: How to Identify and Resolve Radio-TV Interference Problems. This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402. Stock No. 004-000-00345-4.

Declaration of the Manufacturer or Importer

We hereby certify that the Fluke Model 5700A/5720A Series II Calibrator is in compliance with BMPT Vfg 243/1991 and is RFI suppressed. The normal operation of some equipment (e.g. signal generators) may be subject to specific restrictions. Please observe the notices in the users manual. The marketing and sales of the equipment was reported to the Central Office for Telecommunication Permits (BZT). The right to retest this equipment to verify compliance with the regulation was given to the BZT.

Bescheinigung des Herstellers/Importeurs

Hiermit wird bescheinigt, daβ Fluke Models 5700A/5720A Series II Calibrator in Übereinstimung mit den Bestimmungen der BMPT-AmtsblVfg 243/1991 funk-entstört ist. Der vorschriftsmäßige Betrieb mancher Geräte (z.B. Meßsender) kann allerdings gewissen Einschränkungen unterliegen. Beachten Sie deshalb die Hinweise in der Bedienungsanleitung. Dem Bundesamt für Zulassungen in der Telekcommunikation wurde das Inverkehrbringen dieses Gerätes angezeigt und die Berechtigung zur Überprüfung der Seire auf Einhaltung der Bestimmungen eingeräumt.

Fluke Corporation

OPERATOR SAFETY SUMMARY

WARNING

HIGH VOLTAGE

is used in the operation of this equipment

LETHAL VOLTAGE

may be present on the terminals, observe all safety precautions!

To avoid electrical shock hazard, the operator should not electrically contact the output hi or sense hi binding posts. During operation, lethal voltages of up to 1100V ac or dc may be present on these terminals.

Whenever the nature of the operation permits, keep one hand away from equipment to reduce the hazard of current flowing thought vital organs of the body.

Terms in this Manual

This instrument has been designed and tested in accordance with IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus. This manual contains information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in safe condition.

Warning statements identify conditions or practices that could result in personal injury or loss of life.

Caution statements identify conditions or practices that could result in damage to the equipment or other property.

Symbols Marked on Equipment

⚡	DANGER — High Voltage
⏚	Protective ground (earth) terminal
⚠	Attention — refer to the manual. This symbol indicates that information about the usage of a feature is contained in the manual.

Power Source

The 5700A/5720A Series II is intended to operate from a power source that will not apply more than 264V ac rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Use the Proper Fuse

To avoid fire hazard, use only the fuse specified on the line voltage selection switch label, and which is identical in type voltage rating, and current rating.

Grounding the 5700A/5720A Series II

The 5700A/5720A Series II is Safety Class I (grounded enclosure) instruments as defined in IEC 348. The enclosure is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired earth grounded receptacle before connecting anything to any of the 5700A/5720A Series II terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Use the Proper Power Cord

Use only the power cord and connector appropriate for proper operation of a 5700A/5720A Series II in your country.

Use only a power cord that is in good condition.

Refer cord and connector changes to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate the 5700A/5720A Series II in an atmosphere of explosive gas.

Do Not Remove Cover

To avoid personal injury or death, do not remove the 5700A/5720A Series II cover. Do not operate the 5700A/5720A Series II without the cover properly installed. There are no user-serviceable parts inside the 5700A/5720A Series II, so there is no need for the operator to ever remove the cover.

Do Not Attempt to Operate if Protection May be Impaired

If the 5700A/5720A Series II appears damaged or operates abnormally, protection may be impaired. Do not attempt to operate it. When in doubt, have the instrument serviced.

SERVICING SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Also refer to the preceding Operator Safety Summary

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

Use Care When Servicing With Power On

Dangerous voltage exist at many points inside this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Whenever the nature of the operation permits, keep one hand away from equipment to reduce the hazard of current flowing through vital organs of the body.

Do not wear a grounded wrist strap while working on this product. A grounded wrist strap increase the risk of current flowing through the body.

Disconnect power before removing protective panels, soldering, or replacing components.

High voltage may still be present even after disconnecting power.

FIRST AID FOR ELECTRIC SHOCK

Free the Victim From the Live Conductor

Shut off high voltage at once and ground the circuit. If high voltage cannot be turned off quickly, ground the circuit.

If the circuit cannot be broken or grounded, use a board, dry clothing, or other nonconductor to free the victim.

Get Help!

Yell for help. Call an emergency number. Request medical assistance.

Never Accept Ordinary and General Tests for Death

Symptoms of electric shock may include unconsciousness, failure to breathe, absence of pulse, pallor, and stiffness, and severe burns.

Treat the Victim

If the victim is not breathing, begin CPR or mouth-to-mouth resuscitation if you are certified.

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Chapter 1
Introduction and Specifications

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Introduction 1-1.

The Fluke Model 5700A/5720A Series II calibrators are precise instruments that calibrate a wide variety of electrical measuring instruments. These calibrators maintain high accuracy over a wide ambient temperature range, allowing them to test instruments in any environment, eliminating the restrictions to calibrate only in a temperature-controlled standards laboratory. With a 5700A/5720A Series II, you can calibrate precision multimeters that measure ac or dc voltage, ac or dc current, and resistance. The 5720A Series II operates in a similar manner to the 5700A Series II, the difference is that the 5720A Series II has a considerably higher specified accuracy. Option 5700A-03 Wideband AC Voltage, which is available for both the 5700A Series II and the 5720A Series II, extends this workload to include rf voltmeters.

Specifications are provided at the end of this chapter. The calibrator is a fully-programmable precision source of the following:

- DC voltage to 1100V
- AC voltage to 1100V, with output available from 10 Hz to 1.2 MHz.
- AC and DC current to 2.2A, with output available from 10 Hz to 10 kHz
- Resistance in values of $1x10^n$ and $1.9x10^n$ from 1Ω to 100 MΩ, plus a short.
- Optional wideband ac voltage from 300 µV to 3.5V into 50Ω (-57 dBm to +24 dBm), 10 Hz to 30 MHz.

Features of the calibrator include the following:

- Internal environmentally-controlled references allowing the calibrator to maintain full performance over a wide ambient temperature range.
- Automatic meter error calculation obtained through using a simple output adjust knob; the display shows linearity, offset, and scale errors.
- Keys that multiply and divide the output value by 10 to simplify work on meters with calibration points at decade multiples of a fraction of full-scale.
- Programmable entry limits used for restricting the levels that can be keyed into the calibrator, preventing access to levels that may be harmful to equipment or personnel.
- A SPEC key that provides the capability of displaying the instrument's specification at the selected operating point, calibration interval, and specification confidence level.
- An auxiliary current binding post that allows you to calibrate meters with separate current inputs without moving cables.
- Real-time clock and calendar for date stamping reports.
- Offset and scaling modes that simplify linearity testing of multimeters.
- Variable phase reference signal output and phase-lock input.
- Interfaces for Fluke 5725A, 5220A, and 5205A or 5215A Amplifiers.
- Standard IEEE-488 (GPIB) interface, complying with ANSI/IEEE Standards 488.1-1987 and 488.2-1987.
- Selectable normal remote mode or emulation of the Fluke 5100B and 5200A Series calibrators in functions and response to system controller software.
- EIA Standard RS-232C serial data interface for printing, displaying, or transferring internally-stored calibration constants, and for remote control of the calibrator.
- Extensive internal self testing and diagnostics of analog and digital functions.
- A traceable calibration procedure for all modes and ranges that requires only 10V, 1Ω, and 10 kΩ external standards, with only occasional independent verification.
- Fast, simple, automated calibration check providing added confidence between calibration recalls, and data that can be used to document and characterize the calibrator's performance between calibration recalls.

About this Manual 1-2.

This manual provides complete information for installing the calibrator and operating it from the front panel keys and in remote. It also provides a glossary of calibration-related terms as well as general items such as specifications and error code information. The following topics are covered in this manual:

- Installation
- Operating controls and features
- Front panel operation
- Remote operation (IEEE-488 bus or serial port remote control)
- Serial port operation (printing, displaying, or transferring data, and setting up for serial port remote control)
- Operator maintenance, including how to calibrate the 5700A/5720A Series II
- Options and accessories

How to use this Manual 1-3.

Use the following list to find the location of specific information.

- Quick setup procedure: *5700A/5720A Series II Operators Reference Guide*
- Unpacking and setup: Chapter 2.
- Installation and rack mounting: Chapter 2; also the rack mount kit instruction sheet
- AC line power and interface cabling: Chapter 2
- Controls, indicators, and displays: Chapter 3
- Front panel operation: Chapter 4
- Cabling to a UUT (Unit Under Test): Chapter 4
- Using auxiliary amplifiers: Chapter 4
- Self calibration: Chapters 1 and 7
- Remote operation (IEEE-488 or serial): Chapter 5
- Options and accessories: Chapters 2 and 8
- Instrument specifications: The end of this Chapter
- Theory of operation: Chapter 2 of the *5700A/5720A Series II Service Manual*

Additional Instruction Manuals 1-4.

Each of the manuals listed below is shipped with every instrument (the two reference guides are packaged inside this operator's manual). To order additional copies of the manuals, refer to the Fluke Catalog or ask a Fluke sales representative.

The Manual Set provides complete information for the operator and service or maintenance personnel. The set includes the following manuals:

- *5700A/5720A Series II Operators Manual* (P/N 601622) contains operating instructions needed to start up and operate the calibrator.
- *5700A/5720A Series II Operator Reference Guide* (P/N 601648) contains a summary of operating instructions from the Operator Manual including information needed to start up and operate the calibrator. This guide is provided in several languages.
- *5700A/5720A Series II Remote Programming Reference Guide* (P/N 601655) contains a summary of remote commands for the calibrator including the information needed to determine system status using the status byte and registers.
- *5700A/5720A Series II Service Manual* (P/N 601630) provides maintenance and service information including: theory of operation, performance testing, claibration, troublshooting, parts lists, and schematics.

Wideband AC Voltage Module (Option 5700A-03) 1-5.

The Wideband AC Voltage Module (Option 5700A-03) can be installed in both the 5700A and 5720A Series II calibrators. The moodule is a high-accuracy, low-noise, extremely flat ac voltage source for calibrating rf voltmaters, with a frequency range of 10 Hz to 30 MHz. Output is in seven ranges from 300 μV (-57 dBm) to 3.5V (+24 dBm) through a Type N coaxial connector into a 50Ω load. The output level is selected in volts or dBm through either the front panel controls or under remote control.

The wideband module also functions with the calibrator's output adjust controls that let display the error of a wideband meter in either percentage of output or in decibels.

Included with the wideband module are a Type N output cable and a 50Ω terminator. The wideband module is calibrated to the end of its standard-equipment output cable.

Auxiliary Amplifiers 1-6.

Four amplifiers are available to extend the high voltage performance and current range of the calibrator:

- Fluke Model 5725A Amplifier
- Fluke Model 5205A Precision Power Amplifier
- Fluke Model 5215A Precision Power Amplifier
- Fluke Model 5220A Transconductance Amplifier

Interface connectors on the calibrator's rear panel accept cables to directly operate a 5725A, a 5220A, and either a 5205A or 5215A. Three amplifiers can be connected to the calibrator at the same time, but only one output can be active at a time. Once you have connected the amplifiers and configured the calibrator in a setup menu, amplifier operation is controlled by the calibrator.

Chapter 4 provides instructions for operating each amplifier. The general specifications at the end of this chapter include specifications for operating the calibrator with the 5725A. For other amplifier specifications, refer to their instruction manuals. Table 1-1 summarizes the extended capabilities offered by each amplifier. Brief descriptions of the extended capabilities follow.

Table 1-1. Auxiliary Amplifier Data

Model	Mode	Range
5725A Amplifier	ac V	220 to 1100V rms up to 70 mA, 40 Hz to 30 kHz (50 mA < 5 kHz) 220 to 750V rms up to 70 mA, 30 kHz to 100 kHz
	dc I	0 to ±11A
	ac I	1 to 11A rms, 40 Hz to 10 kHz
5205A Precision Power Amplifier	dc V	100 to 1100V and -100 to -1100V rms @ 70 mA
	ac V	220 to 1100V rms @ 200 mA, 10 Hz to 100 kHz
5215A Precision Power Amplifier	ac V	220 to 1100V rms @ 200 mA, 10 Hz to 100 kHz
5220 Transconductance Amplifier	dc I	0 to ±20A
	ac I	2.2 to 20A rms, 10 Hz to 5 kHz

5725A Amplifier 1-7.

The Fluke 5725A Amplifier is an external unit operating under calibrator control to extend ac voltage drive capabilities and both ac and dc current output range. The amplifier adds the following capabilities to the calibrator's 1100V ac range with no compromise in accuracy:

- Frequency limits at higher voltage increase to 100 kHz at 750V, 30 kHz at 1100V.
- Load limit increases to 70 mA for frequencies above 5 kHz.
- Capacitive drive increases to 1000 pF, subject to the maximum output current.

Extended-performance voltage is available at the calibrator's front or rear binding posts, eliminating the need to change cables during a procedure.

A separate set of binding posts on the front panel of the 5725A supplies extended-range ac and dc current outputs. Since most meters have a separate input terminal for the high current ranges, this eliminates the need to change cables during a procedure. The 5725A can also be configured to source all current (both standard calibrator-generated current and its own current) through the 5725A binding posts.

5205A and 5215A Precision Power Amplifiers 1-8.

The Fluke 5205A and 5215A Precision Power Amplifiers extend calibrator high voltage load and frequency capabilities for demanding applications. Both the 5205A or 5215A add the following capabilities to the calibrator 1100V ac voltage range with accuracy sensing at the load point:

- Frequency limit at higher voltage increases to 100 kHz at 1100V.
- Resistive load limit increases to 200 mA.
- Capacitive load limit increases to 1500 pF.

In addition, a 5205A increases the calibrator's 1100V dc load limits to 70 mA and 1500 pF.

A 5205A or 5215A allows the calibrator to reach higher volt-hertz products occasionally called for, and to maintain high accuracy with heavy loads and long cables.

5220A Transconductance Amplifier 1-9.

The Fluke 5220A Transconductance Amplifier extends the ac and dc current capability of the calibrator to 20A. This high-current output lets you calibrate current meters and shunts, as well as the high-current functions of DMMs and VOMs. High compliance voltage means the 5220A can sustain full output current through multi-turn fixtures for calibrating current transformer and Hall-effect probes.

Support Equipment and Services 1-10.

Fluke supports your calibration needs with precision, high-quality equipment and a wide range of services. Depending on your needs, location, and capabilities, you may decide to support your 5700A/5720A Series II calibrator independently or use Fluke services for part, or all, of your support needs. The following paragraphs describe the support equipment and services offered by Fluke for the calibrator. For specifications and ordering instructions for this support equipment and other Fluke instruments, refer to the Fluke catalog, or contact a representative at a Fluke Sales and Service Center.

732B Direct Voltage Reference Standard 1-11.

The Fluke 732B is a rugged, easily transported solid state direct voltage reference standard with a highly predictable 10V output. This predictability allows the Fluke Standards Laboratory, as well as many Fluke customers, to completely eliminate fragile, saturated standard cells. Laboratories still maintain standard cells using the 732A and 732B as a transportable voltage standard, eliminating the need to transport their standard cells. The 732B can be short-circuited, even for extended periods of time, without damage or loss of stability. It maintains full specified stability over a temperature span of 18 to 28 °C.

The calibrator uses a 10V reference standard such as the Fluke 732B in its semi-automated calibration procedure to establish external voltage traceability. Chapter 7 describes this procedure.

732B-200 Direct Volt Maintenance Program (U.S.A. Only) 1-12.

The Fluke 732B-200 Direct Volt Maintenance Program provides your laboratory with NIST-traceable 10V calibration uncertainty as low as 0.6 parts per million.

The program maintains the 732B that you keep in your laboratory. To accomplish this, the following occurs:

1. Fluke sends you a calibrated Fluke-owned 732B standard, together with all necessary connecting cables and instructions for comparison with your 10V reference standard.
2. You take a series of readings over a five-day period, and return the results to the Fluke Standards Laboratory.
3. The Fluke Standards Laboratory assigns a value to your 10V standard relative to the NIST legal volt and sends you a report of calibration.

742A Series Resistance Standards 1-13.

The calibrator uses 1Ω and 10 kΩ resistor standards such as the 742A Series in its semi-automated calibration procedure to establish external traceability of resistance and current. Chapter 7 describes this procedure.

The 742A Resistance Standards, which are constructed of arrays of Fluke wirewound precision resistors, are ideally suited as support standards for the calibrator. Stability of the resistance transfer standards and their temperature coefficients make them ideal for easy transport to and operation in the calibrator's working environment.

Wideband AC Module (Option 5700A-03) Calibration Support 1-14.

The Wideband AC Module (Option 5700A-03) requires two kinds of calibration: gain and flatness. Gain constants are checked and recalibrated as a part of the normal calibrator semi-automated calibration process.

Since frequency flatness is determined by such stable parameters as circuit geometry and dielectric constants, flatness of the Wideband AC module has excellent long-term stability. This stability gives the Wideband AC Module a two-year calibration cycle for flatness calibration. Flatness calibration is required only infrequently, and can be done when the calibrator is returned to a standards laboratory for periodic verification. The *5700A/5720A Series II Service Manual* contains the wideband flatness calibration procedure. Chapter 7 of this manual contains the wideband gain calibration procedure.

Service Centers 1-15.

A worldwide network of Fluke service centers supports Fluke instruments and assists customers in many ways. (A complete list of service centers is provided in the *5700A/5720A Series II Service Manual.*) Most service centers have standards and calibration laboratories certified by local national standards organizations. The following is a partial list of the services provided by most service centers:

- Repair and certified traceable calibration of all Fluke products.
- Certified traceable calibration of many non-Fluke standards and calibrators.
- Worldwide exchange of calibrator internal modules. Delivery inside the U.S.A. is typically within 48 hours.
- Service agreements with the flexibility to suit your needs. These can be a simple warranty extension or an agreement that includes on-site support. Calibration service agreements are also available in many areas.
- Training programs and seminars, including laboratory metrology, system applications, and product maintenance.
- Application help and consulting, including system design, hardware selection, custom software, site evaluation and installation.
- Replacement parts inventory, including recommended spare parts and module kits.

The Components of the 5700A/5720A Series II Calibrator 1-16.

The calibrator is configured internally as an automated calibration system, with process controls and consistent procedures. Internal microprocessors control all functions and monitor performance, using a switching matrix to route signals between modules. Complete automatic internal diagnostics, both analog and digital, confirm operational integrity.

Reference amplifiers maintain dc accuracy and stability. Of all technologies available, reference amplifiers have the lowest noise and best stability. Reference amplifiers in the calibrator go through special selection processes including long-term aging to ensure high reliability and performance well within specifications.

The calibrator achieves its exceptional ac voltage accuracy by using a patented Fluke rms sensor to make real-time ac/dc comparison measurements. The Fluke rms sensor is similar in principle to the traditional thermal voltage converter, but has a shorter time constant, virtually no reversal error, higher signal-to-noise ratio, and better frequency response. In the calibrator, one Fluke rms sensor serves as an ac/dc transfer standard to develop gain and flatness correction constants during calibration. The second Fluke rms sensor continuously monitors and corrects output voltage during operation.

A patented 26-bit digital-to-analog converter (dac) provides the calibrator with the ability to precisely vary its output. This is a pulse-width modulated dac with linearity typically better than 0.2 ppm of full scale. As with the other internal functions, the linearity of the dac is automatically checked during calibration and analog diagnostics.

Calibrating the 5700A/5720A Series II Calibrator 1-17.

The traditional practice of returning a calibrator to a standards laboratory at regular intervals for a full calibration is time consuming, expensive, and disruptive to the task to which the calibrator is being applied. Moreover, it leaves gaps in confidence. You must rely on manufacturer's specifications to determine if a calibrator will perform acceptably in an operating environment outside the lab. Also, you must assume that drift is predictable enough so that performance is within limits between recalls.

The 5700A/5720A Series II Calibrator makes use of Fluke design breakthroughs in the use of internal check standards and measurement systems. As a result, it can be completely calibrated in place to full specifications using a small number of convenient, portable, environmentally tolerant standards available from Fluke. As you will see below, this procedure is traceable to military standard requirements.

When manufactured, each calibrator is calibrated and thoroughly verified with process metrology and calibration standards traceable to the U.S. National Bureau of Standards. A certificate of calibration is included.

A calibration verification procedure described in the *5700A/5720A Series II Service Manual* is recommended every two years, or as required by your established policies. This procedure involves no adjustments. It simply ensures internal processes are in control, and establishes parallel external traceability paths for internal functions such as ac transfers that are never adjusted or corrected.

Figure 1-1 illustrates the time and money that can be saved by using the 5700A/5720A Series II calibration support plan recommended by Fluke. Depending on your policies, you may initially decide to perform calibration verification more often. The calibrator makes this unnecessary and offers you a practical way to collect data unavailable with a traditional calibrator design about performance between calibrations.

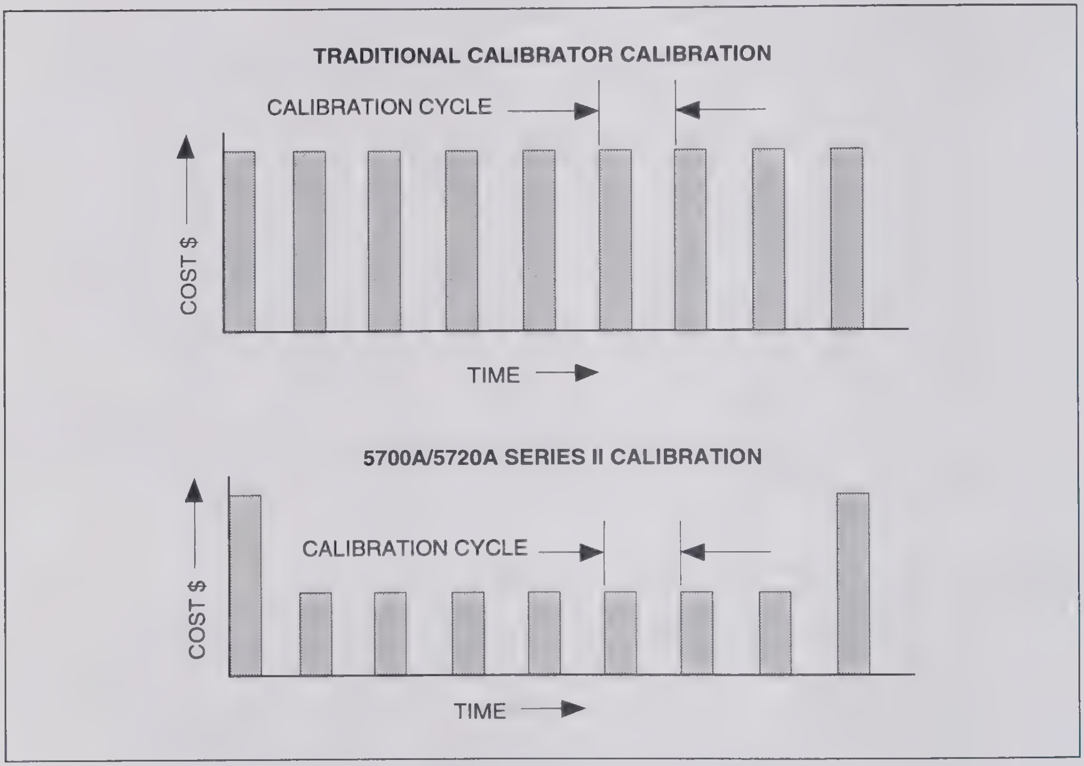


Figure 1-1. Time and Costs: Calibrator Calibration

The Calibration Process 1-18.

Calibration requires only three external standards: 10V, 1Ω, and 10 kΩ. Environmentally-controlled internal check standards provide the primary reference points. A stored table of calibration constants defines additional reference points for controlling the output. Traceable calibration and adjustment to the specified level of performance is accomplished in a semi-automated process that revises this table.

When you finish calibration, but before you save the new constants, the calibrator presents you with the proposed adjustments as +/- ppm of range and percentage change in specification for each range and function. You can print a list of changes through the serial (RS-232C) port, or send them to a computer through either the serial port or the IEEE-488 port. Also on completion of calibration, the calibrator displays the largest proposed change.

Calibration can be completed as far as deriving and printing the proposed adjustments without changing the setting of the rear panel CALIBRATION switch; however, the switch must be set to ENABLE to store the changes in nonvolatile memory and make them effective. The switch is recessed to allow the metrologist to cover it with a calibration sticker to guarantee calibrator integrity.

Establishment of Traceability 1-19.

Traceability to national standards is established as follows:

- Except for the internal ac/dc transfer standard, the internal check standards are directly calibrated by traceable external standards every time the 5700A/5720A Series II is calibrated.
- The internal ac/dc transfer standard is never adjusted, so its traceability is not disturbed by calibration. Infrequent verification is done in the traditional way, by comparing selected ac voltage outputs with an external dc voltage standard through an external ac/dc transfer standard. Fluke recommends this be done every two years, or as determined by the policy of your organization.
- Infrequent independent verification is also performed on stable parameters, such as frequency flatness, determined more by circuit geometry and dielectric constants than time.

Calibration Reports 1-20.

The calibrator stores two sets of calibration constants: the set currently in use and the old set from the previous calibration. This gives the calibrator the ability at any time to produce a calibration report of the differences between the present settings and the settings that were in effect before the last calibration. The report shows changes for each range and function in +/- ppm of range and in percentage of specification limit. You can print the report or send it to a host computer through either the RS-232-C or IEEE-488 interface.

If you request a calibration report after doing calibration but before saving the new constants, the report shows proposed changes to the calibration constants relative to the previously stored settings.

Calibration Check 1-21.

Checking the calibration takes about an hour, and provides you with a means of documenting the calibrator's performance of a between calibrations. Calibration checking is similar to calibration, except internal check standards are used as primary references (no external standards are needed), and changes cannot be stored. The process produces a report similar to normal calibration, showing drift relative to internal check standards. Because cal check does not change stored calibration constants, there is no need to enable the rear panel CALIBRATION switch. Therefore, an external computer can do the procedure unattended.

Developing a Performance History 1-22.

A Fluke specification is a set of performance limits that all products must meet. To maintain consistent quality, Fluke calibrators are specified with enough margin to include temperature, line, and load extremes, plus additional margin for production. This means that a typical 5700A/5720A Series II calibrator in a typical environment operates inside 50% of specification limits. For some exacting applications, it can be helpful to know just how accurately a particular calibrator operates. The proper way to do this is to accumulate a performance history by calibrating regularly and recording results on a control chart.

Calibrating regularly and recording the results on a control chart is tedious and requires a large array of equipment. The calibrator's calibration check feature is an alternative with some distinct advantages:

- Calibrated check standards are already programmed into the unit. You do not have to use external standards.
- The process is consistent and automatic: it does not require an operator's assistance.

Each calibration check produces a new set of data points for accumulating a historical record. When this process is externally automated, significant history can be accumulated much faster than with a manual calibration.

Range Calibration 1-23.

After calibration, you can make further fine adjustments to each range. Range adjustments are optional; they are not necessary to meet total uncertainty specifications. However, they do allow you to align your calibrator closer to your standards.

Before you do range calibration, you must first use the calibrator's semi-automated calibration procedure. This is to calibrate the ranges that will not be adjusted. It also performs an initial adjustment for each range, and supplies flatness corrections for ac functions.

DC Zeros Calibration 1-24.

To ensure the validity of the specifications, a dc zeros calibration must be performed at least every 30 days. If more than 30 days elapse without a dc zeros calibraiton a warning message appears. This procedure does not require any external equipment or connections and takes approximately 2.5 minutes to complete.

Specifications *1-25.*

The 5700A/5720A Series II calibrators are verified and calibrated at the factory prior to shipment to ensure they meet the accuracy standards required for all certified calibration laboratories. By calibrating to the specifications in this chapter, you can maintain the high performance level throughout the life of your calibrator.

Specifications are valid after a warm-up period of twice the time the calibrator has been turned off, up to a maximum of 30 minutes. For example, if the calibrator has been turned off for five minutes, the warm-up period is ten minutes.

Specification Confidence Levels *1-26.*

You calibrator's performance level is ensured by regular calibration to the primary performance specifications, which are provided at both the 99% and 95% confidence levels. The 95% confidence level will provide an accuracy that surpasses the accuracy requirements for meeting Tag 4 standards, or a coverage factor of 2. Calibration at the 99% confidence level is also available for those applications that require a confidence factor for the specifications that is higher than 95%. For information on selecting the confidence level, refer to Chapter 4.

The tables in this chapter provide specifications at both the 95% and 99% confidence levels for the 5700A/5720A Series II calibrators. Included with these tables are operating specifications for using the calibrator with the Wideband AC Module (Option 5700A-03) and the 5725A Amplifier.

Using Absolute and Relative Uncertainty Specifications *1-27.*

To evaluate the 5700A/5720A Series II coverage of your calibration workload, use the Absolute Uncertainty specifications. Absolute uncertainty includes stability, temperature coefficient, linearity, line and load regulation, and the traceability to external standards. You do not need to add anything to absolute uncertainty to determine the ratios between the calibrator's uncertainties and the uncertainties of your calibration workload.

Relative uncertainty specifications are provided for enhanced accuracy applications. These specifications apply when range constants are adjusted (see “Range Calibration”). To calculate absolute uncertainty, you must combine the uncertainties of your external standards and techniques with relative uncertainty.

Using Secondary Performance Specifications *1-28.*

Secondary performance specifications and operating characteristics are included in uncertainty specifications. They are provided for special calibration requirements such as stability or linearity testing.

DC Voltage Specifications 1-29.

Table 1-2. 5720A Series II DC Voltage Specifications: 99% and 95% Confidence Levels

5720A 99%

99% Confidence Level

Range	Resolution	Absolute Uncertainty ± 5°C from calibration temperature For fields strengths >1 V/m but ≤3 V/m, add 0.01% of range.				Relative Uncertainty ± 1°C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		± (ppm output + μV)				± (ppm output + μV)	
220 mV	10 nV	5 + 0.5	7 + 0.5	8 + 0.5	9 + 0.5	2 + 0.4	2.5 + 0.4
2.2V	100 nV	3.5 + 0.8	4 + 0.8	4.5 + 0.8	6 + 0.8	2 + 0.8	2.5 + 0.8
11V	1 μV	2.5 + 3	3 + 3	3.5 + 3	4 + 3	1 + 3	1.5 + 3
22V	1 μV	2.5 + 5	3 + 5	3.5 + 5	4 + 5	1 + 5	1.5 + 5
220V	10 μV	3.5 + 50	4 + 50	5 + 50	6 + 50	2 + 50	2.5 + 50
1100V	100 μV	5 + 500	6 + 500	7 + 500	8 + 500	2.5 + 400	3 + 400

5720A 95%

95% Confidence Level

Range	Resolution	Absolute Uncertainty ± 5°C from calibration temperature For fields strengths >1 V/m but ≤3 V/m, add 0.01% of range.				Relative Uncertainty ± 1°C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		± (ppm output + μV)				± (ppm output + μV)	
220 mV	10 nV	4 + 0.4	6 + 0.4	6.5 + 0.4	7.5 + 0.4	1.6 + 0.4	2 + 0.4
2.2V	100 nV	3 + 0.7	3.5 + 0.7	4 + 0.7	5 + 0.7	1.6 + 0.7	2 + 0.7
11V	1 μV	2 + 2.5	2.5 + 2.5	3 + 2.5	3.5 + 2.5	0.8 + 2.5	1.2 + 2.5
22V	1 μV	2 + 4	2.5 + 4	3 + 4	3.5 + 4	0.8 + 4	1.2 + 4
220V	10 μV	3 + 40	3.5 + 40	4 + 40	5 + 40	1.6 + 40	2 + 40
1100V	100 μV	4 + 400	4.5 + 400	6 + 400	6.5 + 400	2 + 400	2.4 + 400

Table 1-3. 5700A Series II DC Voltage Specifications: 99% and 95% Confidence Levels

5700A 99%

99% Confidence Level

Range	Resolution	Absolute Uncertainty ± 5°C from calibration temperature For fields strengths >1 V/m but ≤3 V/m, add 0.01% of range.				Relative Uncertainty ± 1°C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		± (ppm output + μV)				± (ppm output + μV)	
220 mV	10 nV	6.5 + .75	7 + .75	8 + .75	9 + .8	2.5 + .5	4 + .5
2.2V	100 nV	3.5 + 1.2	6 + 1.2	7 + 1.2	8 + 1.2	2.5 + 1.2	4 + 1.2
11V	1 μV	3.5 + 3	5 + 4	7 + 4	8 + 4	1.5 + 3	3.5 + 4
22V	1 μV	3.5 + 6	5 + 8	7 + 8	8 + 8	1.5 + 6	3.5 + 8
220V	10 μV	5 + 100	6 + 100	8 + 100	9 + 100	2.5 + 100	4 + 100
1100V	100 μV	7 + 600	8 + 600	10 + 600	11 + 600	3 + 600	4.5 + 600

5700A 95%

95% Confidence Level

Range	Resolution	Absolute Uncertainty ± 5°C from calibration temperature For fields strengths >1 V/m but ≤3 V/m, add 0.01% of range.				Relative Uncertainty ± 1°C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		± (ppm output + μV)				± (ppm output + μV)	
220 mV	10 nV	5.5 + 0.6	6 + 0.6	7 + 0.6	8 + 0.6	2 + 0.4	3.5 + 0.4
2.2V	100 nV	3.5 + 1	5 + 1	6 + 1	7 + 1	2 + 1	3.5 + 1
11V	1 mV	3 + 3.5	4 + 3.5	6 + 3.5	7 + 3.5	1.2 + 3	3 + 3.5
22V	1 mV	3 + 6.5	4 + 6.5	6 + 6.5	7 + 6.5	1.2 + 6	3 + 7
220V	10 mV	4 + 80	5 + 80	7 + 80	8 + 80	2 + 80	3.5 + 80
1100V	100 mV	6 + 500	7 + 500	8 + 500	9 + 500	2.4 + 500	4 + 500

Table 1-4. DC Voltage Secondary Performance Specifications and Operating Characteristics

Range	Stability [Note 1] ± 1°C 24 Hours	Temperature Coefficient Adder [Note 2]		Linearity ± 1°C	Noise	
		10°-40°C	0°-10°C and 40°-50°C		Bandwidth 0.1-10 Hz pk-pk	Bandwidth 10-10 kHz RMS
	± (ppm output + μV)	± (ppm output + μV)/°C		± (ppm output + μV)		μV
220 mV	0.3 + 0.3	0.4 + 0.1	1.5 + 0.5	1 + 0.2	0.15 + 0.1	5
2.2V	0.3 + 1	0.3 + 0.1	1.5 + 2	1 + 0.6	0.15 + 0.4	15
11V	0.3 + 2.5	0.15 + 0.2	1 + 1.5	0.3 + 2	0.15 + 2	50
22V	0.4 + 5	0.2 + 0.4	1.5 + 3	0.3 + 4	0.15 + 4	50
220V	0.5 + 40	0.3 + 5	1.5 + 40	1 + 40	0.15 + 60	150
1100V	0.5 + 200	0.5 + 10	3 + 200	1 + 200	0.15 + 300	500

Notes:

1. Stability specifications are included in the Absolute Uncertainty values in the primary specification tables.
2. Temperature coefficient is an adder to uncertainty specifications that does *not* apply unless operating more than ±5°C from calibration temperature.

Minimum output: 0V for all ranges, except 100V for 1100V range

Maximum load: 50 mA for 2.2V through 220V ranges; 20 mA for 1100V range; 50W output impedance on 220 mV range; all ranges <1000 pF,>25W

Load regulation: <0.2 ppm + 0.2 mV change, full load to no load

Line regulation: <0.1 ppm change, ± 10% of selected nominal line

Settling time: 3 seconds to full accuracy; + 1 second for range or polarity change; + 1 second for 1100V range

Overshoot: <5%

Common mode rejection: 140 dB, DC to 400 Hz

Remote sensing: Available 0V to ±1100V, on 2.2V through 1100V ranges

AC Voltage Specifications

1-30.

Table 1-5. 5720A Series II AC Voltage Specifications: 99% Confidence Level

5720A
99%

99% Confidence Level

Range	Resolution	Frequency	Absolute Uncertainty ± 5°C from calibration temperature				Relative Uncertainty ± 1°C	
			24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		Hz	± (ppm output + μV)				± (ppm output + μV)	
2.2 mV	1 nV	10 - 20	250 + 5	270 + 5	290 + 5	300 + 5	250 + 5	270 + 5
		20 - 40	100 + 5	105 + 5	110 + 5	115 + 5	100 + 5	105 + 5
		40 - 20k	85 + 5	90 + 5	95 + 5	100 + 5	60 + 5	65 + 5
		20k - 50k	220 + 5	230 + 5	240 + 5	250 + 5	85 + 5	95 + 5
		50k - 100k	500 + 6	540 + 6	570 + 6	600 + 6	200 + 6	220 + 6
		100k - 300k	1000 + 12	1200 + 12	1250 + 12	1300 + 12	350 + 12	400 + 12
		300k - 500k	1400 + 25	1500 + 25	1600 + 25	1700 + 25	800 + 25	1000 + 25
		500k - 1M	2900 + 25	3100 + 25	3250 + 25	3400 + 25	2700 + 25	3000 + 25
22 mV	10 nV	10 - 20	250 + 5	270 + 5	290 + 5	300 + 5	250 + 5	270 + 5
		20 - 40	100 + 5	105 + 5	110 + 5	115 + 5	100 + 5	105 + 5
		40 - 20k	85 + 5	90 + 5	95 + 5	100 + 5	60 + 5	65 + 5
		20k - 50k	220 + 5	230 + 5	240 + 5	250 + 5	85 + 5	95 + 5
		50k - 100k	500 + 6	540 + 6	570 + 6	600 + 6	200 + 6	220 + 6
		100k - 300k	1000 + 12	1200 + 12	1250 + 12	1300 + 12	350 + 12	400 + 12
		300k - 500k	1400 + 25	1500 + 25	1600 + 25	1700 + 25	800 + 25	1000 + 25
		500k - 1M	2900 + 25	3100 + 25	3250 + 25	3400 + 25	2700 + 25	3000 + 25
220 mV	100 nV	10 - 20	250 + 15	270 + 15	290 + 15	300 + 15	250 + 15	270 + 15
		20 - 40	100 + 8	105 + 8	110 + 8	115 + 8	100 + 8	105 + 8
		40 - 20k	85 + 8	90 + 8	95 + 8	100 + 8	60 + 8	65 + 8
		20k - 50k	220 + 8	230 + 8	240 + 8	250 + 8	85 + 8	95 + 8
		50k - 100k	500 + 20	540 + 20	570 + 20	600 + 20	200 + 20	220 + 20
		100k - 300k	850 + 25	900 + 25	1000 + 25	1100 + 25	350 + 25	400 + 25
		300k - 500k	1400 + 30	1500 + 30	1600 + 30	1700 + 30	800 + 30	1000 + 30
		500k - 1M	2700 + 60	2900 + 60	3100 + 60	3300 + 60	2600 + 60	2800 + 60
2.2V	1 mV	10 - 20	250 + 50	270 + 50	290 + 50	300 + 50	250 + 50	270 + 50
		20 - 40	95 + 20	100 + 20	105 + 20	110 + 20	95 + 20	100 + 20
		40 - 20k	45 + 10	47 + 10	50 + 10	52 + 10	30 + 10	40 + 10
		20k - 50k	80 + 12	85 + 12	87 + 12	90 + 12	70 + 12	75 + 12
		50k - 100k	120 + 40	125 + 40	127 + 40	130 + 40	100 + 40	105 + 40
		100k - 300k	380 + 100	420 + 100	460 + 100	500 + 100	270 + 100	290 + 100
		300k - 500k	1000 + 250	1100 + 250	1150 + 250	1200 + 250	900 + 250	1000 + 250
		500k - 1M	1600 + 400	1800 + 400	1900 + 400	2000 + 400	1200 + 400	1300 + 400
22V	10 mV	10 - 20	250 + 500	270 + 500	290 + 500	300 + 500	250 + 500	270 + 500
		20 - 40	95 + 200	100 + 200	105 + 200	110 + 200	95 + 200	100 + 200
		40 - 20k	45 + 70	47 + 70	50 + 70	52 + 70	30 + 70	40 + 70
		20k - 50k	80 + 120	85 + 120	87 + 120	90 + 120	70 + 120	75 + 120
		50k - 100k	110 + 250	115 + 250	117 + 250	120 + 250	100 + 250	105 + 250
		100k - 300k	300 + 800	310 + 800	320 + 800	325 + 800	270 + 800	290 + 800
		300k - 500k	1000 + 2500	1100 + 2500	1150 + 2500	1200 + 2500	900 + 2500	1000 + 2500
		500k - 1M	1500 + 4000	1600 + 4000	1700 + 4000	1800 + 4000	1300 + 4000	1400 + 4000
			± (ppm output + mV)				± (ppm output + mV)	
220V	100 mV	10 - 20	250 + 5	270 + 5	290 + 5	300 + 5	250 + 5	270 + 5
		20 - 40	95 + 2	100 + 2	105 + 2	110 + 2	95 + 2	100 + 2
		40 - 20k	57 + 0.7	60 + 0.7	62 + 0.7	65 + 0.7	45 + 0.7	50 + 0.7
		20k - 50k	90 + 1.2	95 + 1.2	97 + 1.2	100 + 1.2	75 + 1.2	80 + 1.2
		50k - 100k	160 + 3	170 + 3	175 + 3	180 + 3	140 + 3	150 + 3
		100k - 300k	900 + 20	1000 + 20	1050 + 20	1100 + 20	600 + 20	700 + 20
		300k - 500k	5000 + 50	5200 + 50	5300 + 50	5400 + 50	4500 + 50	4700 + 50
		500k - 1M	8000 + 100	9000 + 100	9500 + 100	10,000 + 100	8000 + 100	8500 + 100
1100V	1 mV [Note 1]	15 - 50	300 + 20	320 + 20	340 + 20	360 + 20	300 + 20	320 + 20
		50 - 1k	70 + 4	75 + 4	80 + 4	85 + 4	50 + 4	55 + 4
5725A Amplifier:								
1100V	1 mV	40 - 1k	75 + 4	80 + 4	85 + 4	90 + 4	50 + 4	55 + 4
		1k - 20k	105 + 6	125 + 6	135 + 6	165 + 6	85 + 6	105 + 6
		20k - 30k	230 + 11	360 + 11	440 + 11	600 + 11	160 + 11	320 + 11
750V		30k - 50k	230 + 11	360 + 11	440 + 11	600 + 11	160 + 11	320 + 11
		50k - 100k	600 + 45	1300 + 45	1600 + 45	2300 + 45	380 + 45	1200 + 45

Note: 1. Maximum output 250V from 15-50 Hz.

Table 1-6. 5720A Series II AC Voltage Specifications: 95% Confidence Level

5720A
95%

95% Confidence Level

Range	Resolution	Frequency	Absolute Uncertainty ± 5°C from calibration temperature				Relative Uncertainty ± 1°C	
			24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		Hz	± (ppm output + µV)				± (ppm output + µV)	
2.2 mV	1 nV	10 - 20	200 + 4	220 + 4	230 + 4	240 + 4	200 + 4	220 + 4
		20 - 40	80 + 4	85 + 4	87 + 4	90 + 4	80 + 4	85 + 4
		40 - 20k	70 + 4	75 + 4	77 + 4	80 + 4	50 + 4	55 + 4
		20k - 50k	170 + 4	180 + 4	190 + 4	200 + 4	70 + 4	80 + 4
		50k - 100k	400 + 5	460 + 5	480 + 5	500 + 5	160 + 5	180 + 5
		100k - 300k	300 + 10	900 + 10	1000 + 10	1050 + 10	280 + 10	320 + 10
		300k - 500k	1100 + 20	1200 + 20	1300 + 20	1400 + 20	650 + 20	800 + 20
		500k - 1M	2400 + 20	2500 + 20	2600 + 20	2700 + 20	2100 + 20	2400 + 20
22 mV	10 nV	10 - 20	200 + 4	220 + 4	230 + 4	240 + 4	200 + 4	220 + 4
		20 - 40	80 + 4	85 + 4	87 + 4	90 + 4	80 + 4	85 + 4
		40 - 20k	70 + 4	75 + 4	77 + 4	80 + 4	50 + 4	55 + 4
		20k - 50k	170 + 4	180 + 4	190 + 4	200 + 4	70 + 4	80 + 4
		50k - 100k	400 + 5	460 + 5	480 + 5	500 + 5	160 + 5	180 + 5
		100k - 300k	300 + 10	900 + 10	1000 + 10	1050 + 10	280 + 10	320 + 10
		300k - 500k	1100 + 20	1200 + 20	1300 + 20	1400 + 20	650 + 20	800 + 20
		500k - 1M	2400 + 20	2500 + 20	2600 + 20	2700 + 20	2100 + 20	2400 + 20
220 mV	100 nV	10 - 20	200 + 12	220 + 12	230 + 12	240 + 12	200 + 12	220 + 12
		20 - 40	80 + 7	85 + 7	87 + 7	90 + 7	80 + 7	85 + 7
		40 - 20k	70 + 7	75 + 7	77 + 7	80 + 7	50 + 7	55 + 7
		20k - 50k	170 + 7	180 + 7	190 + 7	200 + 7	70 + 7	80 + 7
		50k - 100k	400 + 17	420 + 17	440 + 17	460 + 17	160 + 17	180 + 17
		100k - 300k	700 + 20	750 + 20	800 + 20	900 + 20	280 + 20	320 + 20
		300k - 500k	1100 + 25	1200 +25	1300 + 25	1400 + 25	650 + 25	800 + 25
		500k - 1M	2400 + 45	2500 + 45	2600 + 45	2700 + 45	2100 + 45	2400 + 45
2.2V	1 mV	10 - 20	200 + 40	220 + 40	230 + 40	240 + 40	200 + 40	220 + 40
		20 - 40	75 + 15	80 + 15	85 + 15	90 + 15	75 + 15	80 + 15
		40 - 20k	37 + 8	40 + 8	42 + 8	45 + 8	25 + 8	35 + 8
		20k - 50k	65 + 10	70 + 10	73 + 10	75 + 10	55 + 10	60 + 10
		50k - 100k	100 + 30	105 + 30	107 + 30	110 + 30	80 + 30	85 + 30
		100k - 300k	300 + 80	340 + 80	380 + 80	420 + 80	230 + 80	250 + 80
		300k - 500k	800 + 200	900 + 200	950 + 200	1000 + 200	700 + 200	800 + 200
		500k - 1M	1300 + 300	1500 + 300	1600 + 300	1700 + 300	1000 + 300	1100 + 300
22V	10 mV	10 - 20	200 + 400	220 + 400	230 + 400	240 + 400	200 + 400	220 + 400
		20 - 40	75 + 150	80 + 150	85 + 150	90 + 150	75 + 150	80 + 150
		40 - 20k	37 + 50	40 + 50	42 + 50	45 + 50	25 + 50	35 + 50
		20k - 50k	65 + 100	70 + 100	73 + 100	75 + 100	55 + 100	60 + 100
		50k - 100k	90 + 200	95 + 200	97 + 200	100 + 200	80 + 200	85 + 200
		100k - 300k	250 + 600	260 + 600	270 + 600	275 + 600	250 + 600	270 + 600
		300k - 500k	800 + 2000	900 + 2000	900 + 2000	1000 + 2000	700 + 2000	800 + 2000
		500k - 1M	1200 + 3200	1300 + 3200	1400 + 3200	1500 + 3200	1100 + 3200	1200 + 3200
± (ppm output + mV)							± (ppm output + mV)	
220V	100 mV	10 - 20	200 +4	220 + 4	230 + 4	240 + 4	200 + 4	220 + 4
		20 - 40	75 + 1.5	80 + 1.5	85 + 1.5	90 + 1.5	75 + 1.5	80 + 1.5
		40 - 20k	45 + 0.6	47 + 0.6	50 + 0.6	52 + 0.6	35 + 0.6	40 + 0.6
		20k - 50k	70 + 1	75 + 1	77 + 1	80 + 1	60 + 1	65 + 1
		50k - 100k	120 + 2.5	130 + 2.5	140 + 2.5	150 + 2.5	110 + 2.5	120 + 2.5
		100k - 300k	700 + 16	800 + 16	850 + 16	900 + 16	500 + 16	600 + 16
		300k - 500k	4000 + 40	4200 + 40	4300 + 40	4400 + 40	3600 + 40	3800 + 40
		500k - 1M	6000 + 80	7000 + 80	7500 + 80	8000 + 80	6500 + 80	7000 + 80
1100V	1 mV [Note 1]	15 - 50	240 + 16	260 + 16	280 + 16	300 + 16	240 + 16	260 + 16
		50 - 1k	55 + 3.5	60 + 3.5	65 + 3.5	70 + 3.5	40 + 3.5	45 + 3.5
5725A Amplifier:								
1100V	1 mV	40 - 1k	75 + 4	80 + 4	85 + 4	90 + 4	50 + 4	55 + 4
		1k - 20k	105 + 6	125 + 6	135 + 6	165 + 6	85 + 6	105 + 6
		20k - 30k	230 + 11	360 + 11	440 + 11	600 + 11	160 + 11	320 + 11
750V		30k - 50k	230 + 11	360 + 11	440 + 11	600 + 11	160 + 11	320 + 11
		50k - 100k	600 + 45	1300 + 45	1600 + 45	2300 + 45	380 + 45	1200 + 45

Note: 1. Maximum output 250V from 15-50 Hz

Table 1-7. 5700A Series II AC Voltage Specifications: 99% Confidence Level

5700A 99%

99% Confidence Level

Range	Resolution	Frequency	Absolute Uncertainty ± 5°C from calibration temperature				Relative Uncertainty ± 1°C	
			24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		Hz	± (ppm output + μV)				± (ppm output + μV)	
2.2 mV	1 nV	10 - 20	500 + 5	550 + 5	600 + 5	600 + 5	500 + 5	550 + 5
		20 - 40	200 + 5	220 + 5	230 + 5	240 + 5	200 + 5	220 + 5
		40 - 20k	100 + 5	110 + 5	120 + 5	120 + 5	60 + 5	65 + 5
		20k - 50k	340 + 5	370 + 5	390 + 5	410 + 5	100 + 5	110 + 5
		50k - 100k	800 + 8	900 + 8	950 + 8	950 + 8	220 + 8	240 + 8
		100k - 300k	1100 + 15	1200 + 15	1300 + 15	1300 + 15	400 + 15	440 + 15
		300k - 500k	1500 + 30	1700 + 30	1700 + 30	1800 + 30	1000 + 30	1100 + 30
		500k - 1M	4000 + 40	4400 + 40	4700 + 40	4800 + 40	400 + 30	4400 + 30
22 mV	10 nV	10 - 20	500 + 6	550 + 6	600 + 6	600 + 6	500 + 6	550 + 6
		20 - 40	200 + 6	220 + 6	230 + 6	240 + 6	200 + 6	220 + 6
		40 - 20k	100 + 6	110 + 6	120 + 6	120 + 6	60 + 6	65 + 6
		20k - 50k	340 + 6	370 + 6	390 + 6	410 + 6	100 + 6	110 + 6
		50k - 100k	800 + 8	900 + 8	950 + 8	950 + 8	220 + 8	240 + 8
		100k - 300k	1100 + 15	1200 + 15	1300 + 15	1300 + 15	400 + 15	440 + 15
		300k - 500k	1500 + 30	1700 + 30	1700 + 30	1800 + 30	1000 + 30	1100 + 30
		500k - 1M	4000 + 40	4400 + 40	4700 + 40	4800 + 40	4000 + 30	4400 + 30
220 mV	100 nV	10 - 20	500 + 16	550 + 16	600 + 16	600 + 16	500 + 16	550 + 16
		20 - 40	200 + 10	220 + 10	230 + 10	240 + 10	200 + 10	220 + 10
		40 - 20k	95 + 10	100 + 10	110 + 10	110 + 10	60 + 10	65 + 10
		20k - 50k	300 + 10	330 + 10	350 + 10	360 + 10	100 + 10	110 + 10
		50k - 100k	750 + 30	800 + 30	850 + 30	900 + 30	220 + 30	240 + 30
		100k - 300k	940 + 30	1000 + 30	1100 + 30	1100 + 30	400 + 30	440 + 30
		300k - 500k	1500 + 40	1700 + 40	1700 + 40	1800 + 40	1000 + 40	1100 + 40
		500k - 1M	3000 + 100	3300 + 100	3500 + 100	3600 + 100	3000 + 100	3300 + 100
2.2V	1 mV	10 - 20	500 + 100	550 + 100	600 + 100	600 + 100	500 + 100	550 + 100
		20 - 40	150 + 30	170 + 30	170 + 30	180 + 30	150 + 30	170 + 30
		40 - 20k	70 + 7	75 + 7	80 + 7	85 + 7	40 + 7	45 + 7
		20k - 50k	120 + 20	130 + 20	140 + 20	140 + 20	100 + 20	110 + 20
		50k - 100k	230 + 80	250 + 80	270 + 80	280 + 80	200 + 80	220 + 80
		100k - 300k	400 + 150	440 + 150	470 + 150	480 + 150	400 + 150	440 + 150
		300k - 500k	1000 + 400	1100 + 400	1200 + 400	1200 + 400	1000 + 400	1100 + 400
		500k - 1M	2000 + 1000	2200 + 1000	2300 + 1000	2400 + 1000	2000 + 1000	2200 + 1000
22V	10 mV	10 - 20	500 + 1000	550 + 1000	600 + 1000	600 + 1000	500 + 1000	550 + 1000
		20 - 40	150 + 300	170 + 300	170 + 300	180 + 300	150 + 300	170 + 300
		40 - 20k	70 + 70	75 + 70	80 + 70	85 + 70	40 + 70	45 + 70
		20k - 50k	120 + 200	130 + 200	140 + 200	140 + 200	100 + 200	110 + 200
		50k - 100k	230 + 400	250 + 400	270 + 400	280 + 400	200 + 400	220 + 400
		100k - 300k	500 + 1700	550 + 1700	550 + 1700	600 + 1700	500 + 1700	550 + 1700
		300k - 500k	1200 + 5000	1300 + 5000	1300 + 5000	1400 + 5000	1200 + 5000	1300 + 5000
		500k - 1M	2600 + 9000	2800 + 9000	2900 + 9000	3000 + 9000	2600 + 9000	2800 + 9000
± (ppm output + mV)							± (ppm output + mV)	
220V	100 mV	10 - 20	500 + 10	550 + 10	600 + 10	600 + 10	500 + 10	550 + 10
		20 - 40	150 + 3	170 + 3	170 + 3	180 + 3	150 + 3	170 + 3
		40 - 20k	75 + 1	80 + 1	85 + 1	90 + 1	45 + 1	50 + 1
		20k - 50k	200 + 4	220 + 4	240 + 4	250 + 4	100 + 1	110 + 1
		50k - 100k	500 + 10	550 + 10	600 + 10	600 + 10	300 + 10	330 + 10
		100k - 300k	1500 + 110	1500 + 110	1600 + 110	1600 + 110	1500 + 110	1500 + 100
		300k - 500k	5000 + 110	5200 + 110	5300 + 110	5400 + 110	5000 + 110	5200 + 110
		500k - 1M	12,000 + 220	12,500 + 220	12,500 + 220	13,000 + 220	12,000 + 220	12,000 + 220
1100V	1 mV [Note 1]	15 - 50	400 + 20	420 + 20	440 + 20	460 + 20	400 + 20	420 + 20
		50 - 1k	75 + 4	80 + 4	85 + 4	90 + 4	50 + 4	55 + 4
5725A Amplifier:								
1100V	1 mV	40 - 1k	75 + 4	80 + 4	85 + 4	90 + 4	50 + 4	55 + 4
		1k - 20k	105 + 6	125 + 6	135 + 6	165 + 6	85 + 6	105 + 6
		20k - 30k	230 + 11	360 + 11	440 + 11	600 + 11	160 + 11	320 + 11
750V		30k - 50k	230 + 11	360 + 11	440 + 11	600 + 11	160 + 11	320 + 11
		50k - 100k	600 + 45	1300 + 45	1600 + 45	2300 + 45	380 + 45	1200 + 45

Note: 1. Maximum output 250V from 15-50 Hz

Table 1-8. 5700A Series II AC Voltage Specifications: 95% Confidence Level

5700A 95%

95% Confidence Level

Range	Resolution	Frequency	Absolute Uncertainty ± 5°C from calibration temperature				Relative Uncertainty ± 1°C	
			24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		Hz	± (ppm output + μV)				± (ppm output + μV)	
2.2 mV	1 nV	10 - 20	400 + 4.5	500 + 4.5	530 + 4.5	550 + 4.5	400 + 4.5	500 + 4.5
		20 - 40	170 + 4.5	190 + 4.5	200 + 4.5	210 + 4.5	170 + 4.5	190 + 4.5
		40 - 20k	85 + 4.5	95 + 4.5	100 + 4.5	105 + 4.5	55 + 4.5	60 + 4.5
		20k - 50k	300 + 4.5	330 + 4.5	350 + 4.5	370 + 4.5	90 + 4.5	100 + 4.5
		50k - 100k	700 + 7	750 + 7	800 + 7	850 + 7	210 + 7	230 + 7
		100k - 300k	900 + 13	1000 + 13	1050 + 13	1100 + 13	380 + 13	420 + 13
		300k - 500k	1300 + 25	1500 + 25	1600 + 25	1700 + 25	900 + 25	1000 + 25
		500k - 1M	2800 + 25	3100 + 25	3300 + 25	3400 + 25	2900 + 25	3200 + 25
22 mV	10 nV	10 - 20	400 + 5	500 + 5	530 + 5	550 + 5	400 + 5	500 + 5
		20 - 40	170 + 5	190 + 5	200 + 5	210 + 5	170 + 5	190 + 5
		40 - 20k	85 + 5	95 + 5	100 + 5	105 + 5	55 + 5	60 + 5
		20k - 50k	300 + 5	330 + 5	350 + 5	370 + 5	90 + 5	100 + 5
		50k - 100k	700 + 7	750 + 7	800 + 7	850 + 7	210 + 7	230 + 7
		100k - 300k	900 + 12	1000 + 12	1050 + 12	1100 + 12	380 + 12	420 + 12
		300k - 500k	1300 + 25	1500 + 25	1600 + 25	1700 + 25	900 + 25	1000 + 25
		500k - 1M	2800 + 25	3100 + 25	3300 + 25	3400 + 25	2900 + 25	3200 + 25
220 mV	100 nV	10 - 20	400 + 13	500 + 13	530 + 13	550 + 13	400 + 13	500 + 13
		20 - 40	170 + 8	190 + 8	200 + 8	210 + 8	170 + 8	190 + 8
		40 - 20k	85 + 8	95 + 8	100 + 8	105 + 8	55 + 8	60 + 8
		20k - 50k	250 + 8	280 + 8	300 + 8	320 + 8	90 + 8	100 + 8
		50k - 100k	700 + 25	750 + 25	800 + 25	850 + 25	210 + 25	230 + 25
		100k - 300k	900 + 25	1000 + 25	1050 + 25	1100 + 25	380 + 25	420 + 25
		300k - 500k	1300 + 35	1500 + 35	1600 + 35	1700 + 35	900 + 35	1000 + 35
		500k - 1M	2800 + 80	3100 + 80	3300 + 80	3400 + 80	2900 + 80	3200 + 80
2.2V	1 mV	10 - 20	400 + 80	450 + 80	480 + 80	500 + 80	400 + 80	450 + 80
		20 - 40	130 + 25	140 + 25	150 + 25	160 + 25	130 + 25	140 + 25
		40 - 20k	60 + 6	65 + 6	70 + 6	75 + 6	35 + 6	40 + 6
		20k - 50k	105 + 16	110 + 16	115 + 16	120 + 16	85 + 16	95 + 16
		50k - 100k	190 + 70	210 + 70	230 + 70	250 + 70	170 + 70	190 + 70
		100k - 300k	350 + 130	390 + 130	420 + 130	430 + 130	340 + 130	380 + 130
		300k - 500k	850 + 350	950 + 350	1000 + 350	1050 + 350	850 + 350	950 + 350
		500k - 1M	1700 + 850	1900 + 850	2100 + 850	2200 + 850	1700 + 850	1900 + 850
22V	10 mV	10 - 20	400 + 800	450 + 800	480 + 800	500 + 800	400 + 800	450 + 800
		20 - 40	130 + 250	140 + 250	150 + 250	160 + 250	130 + 250	140 + 250
		40 - 20k	60 + 60	65 + 60	70 + 60	75 + 60	35 + 60	40 + 60
		20k - 50k	105 + 160	110 + 160	115 + 160	120 + 160	85 + 160	95 + 160
		50k - 100k	190 + 350	210 + 350	230 + 350	250 + 350	170 + 350	190 + 350
		100k - 300k	400 + 1500	450 + 1500	470 + 1500	500 + 1500	400 + 1500	450 + 1500
		300k - 500k	1050 + 4300	1150 + 4300	1200 + 4300	1250 + 4300	1000 + 4300	1100 + 4300
		500k - 1M	2300 + 8500	2500 + 8500	2600 + 8500	2700 + 8500	2200 + 8500	2400 + 8500
			± (ppm output + mV)				± (ppm output + mV)	
220V	100 mV	10 - 20	400 + 8	450 + 8	480 + 8	500 + 8	400 + 8	450 + 8
		20 - 40	130 + 2.5	140 + 2.5	150 + 2.5	160 + 2.5	130 + 2.5	140 + 2.5
		40 - 20k	65 + 0.8	70 + 0.8	75 + 0.8	80 + 0.8	40 + 0.8	45 + 0.8
		20k - 50k	170 + 3.5	190 + 3.5	210 + 3.5	220 + 3.5	85 + 3.5	95 + 3.5
		50k - 100k	400 + 8	450 + 8	480 + 8	500 + 8	270 + 8	300 + 8
		100k - 300k	1300 + 90	1400 + 90	1450 + 90	1500 + 90	1200 + 90	1300 + 90
		300k - 500k	4300 + 90	4500 + 90	4600 + 90	4700 + 90	4200 + 90	4500 + 90
		500k - 1M	10,500 + 190	11,000 + 190	11,300 + 190	11,500 + 190	10,500 + 190	11,000 + 190
1100V	1 mV [Note 1]	15 - 50	340 + 16	360 + 16	380 + 16	400 + 16	340 + 16	360 + 16
		50 - 1k	65 + 3.5	70 + 3.5	75 + 3.5	80 + 3.5	45 + 3.5	50 + 3.5
		5725A Amplifier:						
1100V	1 mV	40 - 1k	75 + 4	80 + 4	85 + 4	90 + 4	50 + 4	55 + 4
		1k - 20k	105 + 6	125 + 6	135 + 6	165 + 6	85 + 6	105 + 6
		20k - 30k	230 + 11	360 + 11	440 + 11	600 + 11	160 + 11	320 + 11
750V		30k - 50k	230 + 11	360 + 11	440 + 11	600 + 11	160 + 11	320 + 11
		50k - 100k	600 + 45	1300 + 45	1600 + 45	2300 + 45	380 + 45	1200 + 45

Note: 1. Maximum output 250V from 15-50 Hz

Table 1-9. AC Voltage Secondary Performance Specifications and Operating Characteristics

Range	Frequency	Stability ± 1°C [Note 1] 24 Hours	Temperature Coefficient		Output Impedance	Maximum Distortion Bandwidth 10 Hz-10 MHz
			10°-40°C	0°-10°C and 40°-50°C		
	Hz	± µV	±µV/°C		Ω	± (% output + µV)
2.2 mV	10 - 20	5	0.05	0.05	50	0.05 + 10
	20 - 40	5	0.05	0.05		0.035 + 10
	40 - 20k	2	0.05	0.05		0.035 + 10
	20k - 50k	2	0.1	0.1		0.035 + 10
	50k - 100k	3	0.2	0.2		0.035 + 10
	100k - 300k	3	0.3	0.3		0.3 + 30
	300k - 500k	5	0.4	0.4		0.3 + 30
	500k - 1M	5	0.5	0.5		1 + 30
22 mV	10 - 20	5	0.2	0.3	50	0.05 + 11
	20 - 40	5	0.2	0.3		0.035 + 11
	40 - 20k	2	0.2	0.3		0.035 + 11
	20k - 50k	2	0.4	0.5		0.035 + 11
	50k - 100k	3	0.5	0.5		0.035 + 11
	100k - 300k	5	0.6	0.6		0.3 + 30
	300k - 500k	10	1	1		0.3 + 30
	500k - 1M	15	1	1		1 + 30
		± (ppm output + µV)	± (ppm output µV)/°C			
220 mV	10 - 20	150 + 20	2 + 1	2 + 1	50	0.05 + 16
	20 - 40	80 + 15	2 + 1	2 + 1		0.035 + 16
	40 - 20k	12 + 2	2 + 1	2 + 1		0.035 + 16
	20k - 50k	10 + 2	15 + 2	15 + 2		0.035 + 16
	50k - 100k	10 + 2	15 + 4	15 + 4		0.035 + 16
	100k - 300k	20 + 4	80 + 5	80 + 5		0.3 + 30
	300k - 500k	100 + 10	80 + 5	80 + 5		0.3 + 30
	500k - 1M	200 + 20	80 + 5	80 + 5		1 + 30
					Load Regulation ±(ppm output+ µV)	
2.2V	10 - 20	150 + 20	50 + 10	50 + 10	10 + 2	0.05 + 80
	20 - 40	80 + 15	15 + 5	15 + 5	10 + 2	0.035 + 80
	40 - 20k	12 + 4	2 + 1	5 + 2	10 + 4	0.035 + 80
	20k - 50k	15 + 5	10 + 2	15 + 4	30 + 10	0.035 + 80
	50k - 100k	15 + 5	10 + 4	20 + 4	120 + 16	0.035 + 80
	100k - 300k	30 + 10	80 + 15	80 + 15	300 ppm	0.3 + 110
	300k - 500k	70 + 20	80 + 40	80 + 40	600 ppm	0.3 + 110
	500k - 1M	150 + 50	80 + 100	80 + 100	1200 ppm	1 + 110
22V	10 - 20	150 + 20	50 + 100	50 + 100	10 + 20	0.05 + 700
	20 - 40	80 + 15	15 + 30	15 + 40	10 + 20	0.035 + 700
	40 - 20k	12 + 8	2 + 10	4 + 15	10 + 30	0.035 + 700
	20k - 50k	15 + 10	10 + 20	20 + 20	30 + 50	0.035 + 700
	50k - 100k	15 + 10	10 + 40	20 + 40	80 + 80	0.035 + 700
	100k - 300k	30 + 15	80 + 150	80 + 150	100 + 700	0.3 + 800
	300k - 500k	70 + 100	80 + 300	80 + 300	200 + 1100	0.3 + 800
	500k - 1M	150 + 100	80 + 500	80 + 500	600 + 3000	2 + 800
220V	10 - 20	150 + 200	50 + 1000	50 + 1000	10 + 200	0.05 + 10,000
	20 - 40	80 + 150	15 + 300	15 + 300	10 + 200	0.05 + 10,000
	40 - 20k	12 + 80	2 + 80	4 + 80	10 + 300	0.05 + 10,000
	20k - 50k	15 + 100	10 + 100	20 + 100	.30 + .600	0.05 + 10,000
	50k - 100k	15 + 100	10 + 500	20 + 500	80 + 3,000	0.1 + 13,000
	100k - 300k	30 + 400	80 + 600	80 + 600	250 + 25,000	1.5 + 50,000
	300k - 500k	100 + 10,000	80 + 800	80 + 800	500 + 50,000	1.5 + 50,000
	500k - 1M	200 + 20,000	80 + 1000	80 + 1000	1000 + 110,000	3.5 + 100,000
		±(ppm output + mV)	±(ppm output)/°C			±(% output)
1100V	15 - 50	150 + 0.5	50	50	10 + 2	0.15
	50 - 1k	20 + 0.5	2	5	10 + 1	0.07

Note: 1. Stability specifications are included in Absolute Uncertainty values for the primary specifications.

Table 1-9. AC Voltage Secondary Performance and Operating Characteristics (continued)

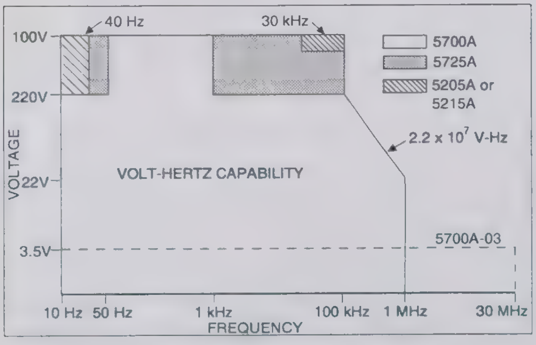
5725A Amplifier:

Range	Frequency	Stability ±1°C [Note 1] 24 Hours	Temperature Coefficient Adder		Load Regulation [Note 2]	Distortion Bandwidth 10 Hz-10 MHz ±(% output)	
			10°-40°C	0°-10°C and 40°-50°C			
	Hz	±(ppm output + mV)	±(ppm output)/°C		±(ppm output + mV)	150 pF	1000 pF
1100V	40 - 1k	10 + .5	5	5	10 + 1	0.10	0.10
	1k - 20k	15 + 2	5	5	90 + 6	0.10	0.15
	20k - 50k	40 + 2	10	10	275 + 11	0.30	0.30
	50k - 100k	130 + 2	30	30	500 + 30	0.40	0.40

Voltage Range	Maximum Current Limits		Load Limits
2.2V [Note 3] 22V 220V	50 mA, 0°C-40°C 20 mA, 40°C-50°C		>50Ω, 1000 pF
1100V	6 mA		600 pF
5725A Amplifier:			1000 pF [Note 2]
1100V	40 Hz-5 kHz	50 mA	
	5 kHz-30 kHz	70 mA	300 pF
	30 kHz-100 kHz	70 mA [Note 4]	150 pF

Notes:

1. Stability specifications are included in Absolute Uncertainty values for the primary specifications.
2. The 5725A will drive up to 1000 pF of load capacitance. Uncertainty specifications include loads to 300 pF and 150 pF as shown under "Load Limits." For capacitances up to the maximum of 1000 pF, add "Load Regulation."
3. 2.2V Range, 100 kHz-1.2 MHz only: uncertainty specifications cover loads to 10 mA or 1000 pF. For higher loads, load regulation is added.
4. Applies from 0°C to 40°C



Output display formats: Voltage or dBm, dBm reference 600Ω.

Minimum output: 10% on each range

External sense: Selectable for 2.2v, 22V, 220V, and 1100V ranges; 5700A/5720A <100 kHz, 5725A <30 kHz

Settling time to full accuracy:

Frequency (Hz)	Settling time (seconds)
<20	7
120-120k	5
>120k	2

+ 1 second for amplitude or frequency range change;
+ 2 seconds for 5700A/5720A 1100V range;
+ 4 seconds for 5725A 1100V range

Overshoot: <10%
Common mode rejection: 140 dB, DC to 400 Hz

Frequency:
Ranges (Hz):
10.000-11.999, 12.00-119.99
120.0-1199.9, 1.200k-11.999k
12.00k-119.99k,120.0k-1.1999
Uncertainty: ±0.01%
Resolution: 11.999 counts

Phase lock: Selectable rear panel BNC input
Phase uncertainty (except 1100V range):
>30 Hz: ±(1° + 0.05°/kHz), <30 Hz: ±3°
Input voltage: 1V to 10V rms sine wave (do not exceed 1V for mV ranges)
Frequency range: 10 Hz to 1.1999 MHz
Lock range: ±2% of frequency
Lock-in time: Larger of 10/frequency or 10 msec

Phase reference: Selectable, rear panel BNC output
Range: ±180°
Phase Uncertainty (except 1100V range):
±1° at quadrature points (0°, ±90°, ±180°) elsewhere ±2°
Stability: ±0.1°
Resolution: 1°
Output level: 2.5V rms ±0.2V
Frequency range:
50 kHz to 1 kHz, usable 10 Hz to 1.1999 MHz

Resistance Specifications *1-31.*

Table 1-10. 5720A Series II Resistance Specifications: 99% and 95% Confidence Levels

5720A 99%

99% Confidence Level

Nominal Value	Absolute Uncertainty of Characterized Value ±5°C from calibration temperature [Note 1]			
	24 Hours	90 Days	180 Days	1 Year
Ω	±ppm			
0	50 μΩ	50 μΩ	50 μΩ	50 μΩ
1	85	95	100	110
1.9	85	95	100	110
10	23	25	26	27
19	23	25	26	27
100	10	11	11.5	12
190	10	11	11.5	12
1k	8	9	9.5	10
1.9k	8	9	9.5	10
10k	8	9	9.5	10
19k	9	9	9.5	10
100k	9	11	12	13
190k	9	11	12	13
1M	16	18	20	23
1.9M	17	19	21	24
10M	33	37	40	46
19M	43	47	50	55
100M	100	110	115	120

Relative Uncertainty ±1°C	
24 Hours	90 Days
±ppm	
50 μΩ	50 μΩ
32	40
25	33
5	8
4	7
2	4
2	4
2	3
2	3
2	3
2	3
2	3
2	3
2.5	5
3	6
10	14
20	24
50	60

5720A 95%

95% Confidence Level

Nominal Value	Absolute Uncertainty of Characterized Value ±5°C from calibration temperature [Note 1]			
	24 Hours	90 Days	180 Days	1 Year
Ω	±ppm			
0	40 μΩ	40 μΩ	40 μΩ	40 μΩ
1	70	80	85	95
1.9	70	80	85	95
10	20	21	22	23
19	20	21	22	23
100	8	9	9.5	10
190	8	9	9.5	10
1k	6.5	7.5	8	8.5
1.9k	6.5	7.5	8	8.5
10k	6.5	7.5	8	8.5
19k	7.5	7.5	8	8.5
100k	7.5	9	10	11
190k	7.5	9	10	11
1M	13	15	17	20
1.9M	15	16	18	21
10M	28	32	35	40
19M	38	42	45	50
100M	85	95	100	100

Relative Uncertainty ±1°C	
24 Hours	90 Days
±ppm	
40 μΩ	40 μΩ
27	35
20	26
4	7
3.5	6
1.6	3.5
1.6	3.5
1.6	2.5
1.6	2.5
1.6	2.5
1.6	2.5
1.6	2.5
1.6	2.5
2	4
2.5	4
8	12
16	20
40	50

Note: 1. Specifications apply to displayed value. 4-wire connections, except 100 MΩ.

Table 1-11. 5700A Series II Resistance Specifications: 99% and 95% Confidence Levels

5700A
99%

99% Confidence Level

Nominal Value	Absolute Uncertainty of Characterized Value ±5°C from calibration temperature [Note 1]			
	24 Hours	90 Days	180 Days	1 Year
Ω	±ppm			
0	50 μΩ	50 μΩ	50 μΩ	50 μΩ
1	85	95	100	110
1.9	85	95	100	110
10	26	28	30	33
19	24	26	28	31
100	15	17	18	20
190	15	17	18	20
1k	11	12	13	15
1.9k	11	12	13	15
10k	9	11	12	14
19k	9	11	12	14
100k	11	13	14	16
190k	11	13	14	16
1M	16	18	20	23
1.9M	17	19	21	24
10M	33	37	40	46
19M	43	47	50	55
100M	110	120	125	130

Relative Uncertainty ±1°C	
24 Hours	90 Days
±ppm	
50 μΩ	50 μΩ
32	40
25	33
5	8
4	7
2	4
2	4
2	3.5
2	3.5
2	3.5
2	3.5
2	3.5
2	3.5
2.5	5
3.5	6
10	14
20	24
50	60

5700A
95%

95% Confidence Level

Nominal Value	Absolute Uncertainty of Characterized Value ±5°C from calibration temperature [Note 1]			
	24 Hours	90 Days	180 Days	1 Year
Ω	±ppm			
0	50 μΩ	50 μΩ	50 μΩ	50 μΩ
1	70	80	85	95
1.9	70	80	85	95
10	21	23	27	28
19	20	22	24	27
100	13	14	15	17
190	13	14	15	17
1k	9	10	11	13
1.9k	9	10	11	13
10k	7.5	9.5	10.5	12
19k	7.5	9.5	10.5	12
100k	9	11	12	14
190k	9	11	12	14
1M	13	15	17	20
1.9M	14	16	18	21
10M	27	31	34	40
19M	35	39	42	47
100M	90	100	105	110

Relative Uncertainty ±1°C	
24 Hours	90 Days
±ppm	
50 μΩ	50 μΩ
32	40
25	33
5	8
4	7
2	4
2	4
2	3.5
2	3.5
2	3.5
2	3.5
2	3.5
2	3.5
2.5	5
3	6
10	14
20	24
50	60

Note: 1. Specifications apply to displayed value. 4-wire connections, except 100 MΩ.

Table 1-12. Resistance Secondary Performance Specifications and Operating Characteristics

Nominal Value	Stability ±1°C [Note 1]	Temperature Coefficient Adder [Note 2]		Full Spec Load Range	Maximum Peak Current	Maximum Difference of Characterized to Nominal Value	Two-Wire Adder active compensation [Note 4]	
							Lead Resistance	
	24 Hours	10°-40°C	0°-10°C and 40°-50°C	[Note 3]			0.1Ω	1Ω
Ω	±ppm	±ppm/°C		mA	mA	±ppm	±mΩ	
0	—	—	—	8 - 500	500	—	2	4
1	32	4	5	8 - 100	700	500	2	4
1.9	25	6	7	8 - 100	500	500	2	4
10	5	2	3	8 - 11	220	300	2	4
19	4	2	3	8 - 11	160	300	2	4
100	2	2	3	8 - 11	70	150	2	4
190	2	2	3	8 - 11	50	150	2	4
1k	2	2	3	1 - 2	22	150	10	15
1.9k	2	2	3	1 - 1.5	16	150	10	15
10k	2	2	3	100 - 500 µA	7	150	50	60
19k	2	2	3	50 - 250 µA	5	150	100	120
100k	2	2	3	10 - 100 µA	1	150		
190k	2	2	3	5 - 50 µA	500 µA	150		
1M	2.5	2.5	6	5 - 20 µA	100 µA	200		
1.9M	3.5	3	10	2.5 - 10 µA	50 µA	200		
10M	10	5	20	0.5 - 2 µA	10 µA	300		
19M	20	8	40	0.25 - 1 µA	5 µA	300		
100M	50	12	100	50 - 200 nA	1 µA	500		

Notes:

1. Stability specifications are included in the Absolute Uncertainty values in the primary specification tables.
2. Temperature coefficient is an adder to uncertainty specifications that does not apply unless operated more than 5°C from calibration temperature, or calibrated outside the range 19°C to 24°C. Two examples:
    - Calibrate at 20°C: Temperature coefficient adder is not required unless operated below 15°C or above 25°C.
    - Calibrate at 26°C: Add 2°C temperature coefficient adder. Additional temperature coefficient adder is not required unless operated below 21°C or above 31°C.
3. Refer to current derating factors table for loads outside of this range.
4. Active two-wire compensation may be selected for values less than 100 kΩ, with either the front panel or the meter input terminals as reference plane. Active compensation is limited to 11 mA load, and to 2V burden. Two wire compensation can be used only with Ω-meters that source continuous (not pulsed) dc current.

Table 1-13. Current Derating Factors

Nominal Value	**Value of Derating Factor K for Over or Under Current**		
Ω	**Two-Wire Comp** $I < I_L$ **[Note 1]**	**Four-Wire** $I < I_L$ **[Note 1]**	**Four-Wire** $I_U < I < I_{max}$ **[Note 2]**
SHORT	4.4	0.3	—
1	4.4	300	4×10^{-5}
1.9	4.4	160	1.5×10^{-4}
10	4.4	30	1.6×10^{-3}
19	4.4	16	3×10^{-3}
100	4.4	3.5	1×10^{-2}
190	4.4	2.5	1.9×10^{-2}
1k	4.4	0.4	0.1
1.9k	4.4	0.4	0.19
10k	5000	50	2.0
19k	5000	50	3.8
100k	—	7.5	2×10^{-5}
190k	—	4.0	3.8×10^{-5}
1M	—	1.0	1.5×10^{-4}
1.9M	—	0.53	2.9×10^{-4}
10M	—	0.2	1×10^{-3}
19M	—	0.53	1.9×10^{-3}
100M		0.1	—

Notes:

1. For $I < I_L$, errors occur due to thermally generated voltages within the 5720A. use the following equation to determine the error, and add this error to the corresponding uncertainty or stability specification.

   Error = $K(I_L - I)/(I_L \times I)$

   Where: Error is in mΩ for all two-wIre comp values and four-wire short, and in ppm for the remaining four-wire values.

   K is the constant from the above table;
   I and I_L are expressed in mA for short to 1.9 kΩ;
   I and I_L are expressed in µA for 10 kΩ to 100 MΩ

2. For $I_U < I < I_{MAX}$ errors occur due to self-heating of the resistors in the calibrator. Use the following equation to determine the error in ppm and add this error to the corresponding uncertainty or stability specification.

   Error in ppm = $K(I^2 - I_U^2)$

Where: K is the constant from the above table;
I and I_U are expressed in mA for short to 19 kΩ;
I and I_U are expressed in µA for 100 kΩ to 100 MΩ

DC Current Specifications *1-32.*

Table 1-14. 5720A Series II DC Current Specifications: 99% and 95% Confidence Levels

5720A 99%

99% Confidence Level

Range	Resolution	Absolute Uncertainty ±5°C from calibration temperature. For fields strengths >0.4 V/m but ≤3 V/m, add 1 % of range.				Relative Uncertainty ±1°C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
	nA	± (ppm output + nA)				± (ppm output + nA)	
220 µA	0.1	40 + 7	42 + 7	45 + 7	50 + 7	24 + 7	26 + 7
2.2 mA	1	30 + 8	35 + 8	37 + 8	40 + 8	24 + 8	26 + 8
22 mA	10	30 + 50	35 + 50	37 + 50	40 + 50	24 + 50	26 + 50
	µA	± (ppm output + µA)				± (ppm output + µA)	
220 mA	0.1	40 + 0.8	45 + 0.8	47 + 0.8	50 + 0.8	26 + 0.5	30 + 0.5
2.2A [Note 1]	1	60 + 15	70 + 15	80 + 15	90 + 15	40 + 12	45 + 12
5725A Amplifier:							
11A	10	330 + 470	340 + 480	350 + 480	360 + 480	100 + 130	110 + 130

5720A 95%

95% Confidence Level

Range	Resolution	Absolute Uncertainty ±5°C from calibration temperature For fields strengths >0.4 V/m but ≤3 V/m, add 1 % of range.				Relative Uncertainty ±1°C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
	nA	± (ppm output + nA)				± (ppm output + nA)	
220 µA	0.1	32 + 6	35 + 6	37 + 6	40 + 6	20 + 6	22 + 6
2.2 mA	1	25 + 7	30 + 7	33 + 7	35 + 7	20 + 7	22 + 7
22 mA	10	25 + 40	30 + 40	33 + 40	35 + 40	20 + 40	22 + 40
	µA	± (ppm output + µA)				± (ppm output + µA)	
220 mA	0.1	35 + 0.7	40 + 0.7	42 + 0.7	45 + 0.7	20 + 0.7	25 + 0.7
2.2A [Note 1]	1	50 + 12	60 + 12	70 + 12	80 + 12	32 + 12	40 + 12
5725A Amplifier:							
11A	10	330 + 470	340 + 480	350 + 480	360 + 480	100 + 130	110 + 130

Note: Maximum output from calibrator terminals is 2.2A. Uncertainty specifications for 220 mA and 2.2 mA ranges are increased by a factor of 1.3 when supplied through 5725A terminals.

Specifications are otherwise identical for all output locations.

1. Add to uncertainty specifications:

   ±200 x I^2 ppm for >100 mA on 220 mA range
   ±10 x I^2 ppm for >1A on 2.2A range

Table 1-15. 5700A Series II DC Current Specifications: 99% and 95% Confidence Levels

5700A 99%

99% Confidence Level

Range	Resolution	Absolute Uncertainty ±5°C from calibration temperature For fields strengths >0.4 V/m but ≤3 V/m, add 1% of range.				Relative Uncertainty ±1°C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
	nA	± (ppm output + nA)				± (ppm output + nA)	
220 µA	0.1	45 + 10	50 + 10	55 + 10	60 + 10	24 + 2	26 + 2
2.2 mA	1	45 + 10	50 + 10	55 + 10	60 + 10	24 + 5	26 + 5
22 mA	10	45 + 100	50 + 100	55 + 100	60 + 100	24 + 50	26 + 50
	µA	± (ppm output + µA)				± (ppm output + µA)	
220 mA	0.1	55 + 1	60 + 1	65 + 1	70 + 1	26 + .3	30 + .3
2.2A [Note 1]	1	75 + 30	80 + 30	90 + 30	95 + 30	40 + 7	45 + 7
5725A Amplifier:							
11A	10	330 + 470	340 + 480	350 + 480	360 + 480	100 + 130	110 + 130

5700A 95%

95% Confidence Level

Range	Resolution	Absolute Uncertainty ±5°C from calibration temperature For fields strengths >0.4 V/m but ≤3 V/m, add 1 % of range.				Relative Uncertainty ±1°C	
		24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
	nA	± (ppm output + nA)				± (ppm output + nA)	
220 µA	0.1	35 + 8	40 + 8	45 + 8	50 + 8	20 + 1.6	22 + 1.6
2.2 mA	1	35 + 8	40 + 8	45 + 8	50 + 8	20 + 4	22 + 4
22 mA	10	35 + 80	40 + 80	45 + 80	50 + 80	20 + 80	22 + 80
	µA	± (ppm output + µA)				± (ppm output + µA)	
220 mA	0.1	45 + 0.8	50 + 0.8	55 + 0.8	60 + 0.8	22 + 0.25	25 + 0.25
2.2A [Note 1]	1	60 + 25	65 + 25	75 + 25	80 + 25	35 + 6	40 + 6
5725A Amplifier:							
11A	10	330 + 470	340 + 480	350 + 480	360 + 480	100 + 130	110 + 130

Note: Maximum output from the calibrator's terminals is 2.2A. Uncertainty specifications for 220 mA and 2.2 mA ranges are increased by a factor of 1.3 when supplied through 5725A terminals.

Specifications are otherwise identical for all output locations.

1. Add to uncertainty specifications:

   $\pm 200 \times I^2$ ppm for >100 mA on 220 mA range
   $\pm 10 \times I^2$ ppm for >1A on 2.2A range

Table 1-16. DC Current Secondary Performance Specifications and Operating Characteristics

Range	Stability ±1°C [Note 1] 24 Hours	Temperature Coefficient [Note 2]		Compliance Limits	Burden Voltage Adder [Note 3]	Maximum Load for Full Accuracy [Note 4]	Noise	
		10°-40°C	0°-10°C and 40°-50°C				Bandwidth 0.1-10 Hz pk-pk	Bandwidth 10-10 kHz RMS
	± (ppm output + nA)	± (ppm output + nA)/°C			±nA/V	Ω	ppm output + nA	nA
220 µA	5 + 1	1 + 0.40	3 + 1	10	0.2	20k	6 + .9	10
2.2 mA	5 + 5	1 + 2	3 + 10	10	0.2	2k	6 + 5	10
22mA	5 + 50	1 + 20	3 + 100	10	10	200	6 + 50	50
220 mA	8 + 300	1 + 200	3 + 1 µA	10	100	20	9 + 300	500
2.2A	9 + 7 µA	1 + 2.5 µA	3 + 10 µA	3 [Note 5]	2 µA	2	12 + 1.5 µA	20 µA
5725A	**± (ppm output + µA)**	**± (ppm output + µA)/°C**					**ppm output + µA**	**µA**
11A	25 + 100	20 + 75	30 + 120	4		4	15 + 70	175

Notes:

Maximum output from the calibrator's terminals is 2.2A. Uncertainty specifications for 220 mA and 2.2 mA ranges are increased by a factor of 1.3 when supplied through 5725A terminals.

1. Stability specifications are included in the Absolute Uncertainty values for the primary specifications.
2. Temperature coefficient is an adder to uncertainty specifications. It does not apply unless operating more than ±5°C from calibration temperature.
3. Burden voltage adder is an adder to uncertainty specifications that does not apply unless burden voltage is greater than 0.5V.
4. For higher loads, multiply uncertainty specification by: $1+\frac{0.1 \text{ x actual load}}{\text{maximum load for full accuracy}}$
5. The calibrator's compliance limit is 2V for outputs from 1A to 2.2A. 5725A Amplifier may be used in range-lock mode down to 0A.

Minimum output: 0 for all ranges, including 5725A.

Settling time to full accuracy: 1 second for mA and mA ranges; 3 seconds for 2.2A range; 6 seconds for 11A range; + 1 second for range or polarity change

Overshoot: <5%

AC Current Specifications *1-33.*

Table 1-17. 5720A Series II AC Current Specifications: 99% Confidence Level

5720A
99%

99% Confidence Level

Range	Resolution	Frequency	Absolute Uncertainty ±5°C from calibration temperature For fields strengths >0.4 V/m but ≤3 V/m, add 1 % of range.				Relative Uncertainty ±1°C	
			24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		Hz	± (ppm output + nA)				± (ppm output + nA)	
220 μA	1 nA	10 - 20	260 + 20	280 + 20	290 + 20	300 + 20	260 + 20	280 + 20
		20 - 40	170 + 12	180 + 12	190 + 12	200 + 12	130 + 12	150 + 12
		40 - 1k	120 + 10	130 + 10	135 + 10	140 + 10	100 + 10	110 + 10
		1k - 5k	300 + 15	320 + 15	340 + 15	350 + 15	250 + 15	280 + 15
		5k - 10k	1000 + 80	1100 + 80	1200 + 80	1300 + 80	900 + 80	1000 + 80
2.2 mA	10 nA	10 - 20	260 + 50	280 + 50	290 + 50	300 + 50	260 + 50	280 + 50
		20 - 40	170 + 40	180 + 40	190 + 40	200 + 40	130 + 40	150 + 40
		40 - 1k	120 + 40	130 + 40	135 + 40	140 + 40	100 + 40	110 + 40
		1k - 5k	210 + 130	220 + 130	230 + 130	240 + 130	250 + 130	280 + 130
		5k - 10k	1000 + 800	1100 + 800	1200 + 800	1300 + 800	900 + 800	1000 + 800
22 mA	100 nA	10 - 20	260 + 500	280 + 500	290 + 500	300 + 500	260 + 500	280 + 500
		20 - 40	170 + 400	180 + 400	190 + 400	200 + 400	130 + 400	150 + 400
		40 - 1k	120 + 400	130 + 400	135 + 400	140 + 400	100 + 400	110 + 400
		1k - 5k	210 + 700	220 + 700	230 + 700	240 + 700	250 + 700	280 + 700
		5k - 10k	1000 + 6000	1100 + 6000	1200 + 6000	1300 + 6000	900 + 6000	1000 + 6000
		Hz	± (ppm output + μA)				± (ppm output + μA)	
220 mA	1 μA	10 - 20	260 + 5	280 + 5	290 + 5	300 + 5	260 + 5	280 + 5
		20 - 40	170 + 4	180 + 4	190 + 4	200 + 4	130 + 4	150 + 4
		40 - 1k	120 + 3	130 + 3	135 + 3	140 + 3	100 + 3	110 + 3
		1k - 5k	210 + 4	220 + 4	230 + 4	240 + 4	250 + 4	280 + 4
		5k - 10k	1000 + 12	1100 + 12	1200 + 12	1300 + 12	900 + 12	1000 + 12
2.2A	10 μA	20 - 1k	290 + 40	300 + 40	310 + 40	320 + 40	300 + 40	350 + 40
		1k - 5k	440 + 100	460 + 100	480 + 100	500 + 100	500 + 100	520 + 100
		5k - 10k	6000 + 200	7000 + 200	7500 + 200	8000 + 200	6000 + 200	7000 + 200
5725A Amplifier:								
11A	100 μA	40 - 1k	370 + 170	400 + 170	440 + 170	460 + 170	300 + 170	330 + 170
		1k - 5k	800 + 380	850 + 380	900 + 380	950 + 380	700 + 380	800 + 380
		5k - 10k	3000 + 750	3300 + 750	3500 + 750	3600 + 750	2800 + 750	3200 + 750

Note: Maximum output from the calibrator's terminals is 2.2A. Uncertainty specifications for 220 μA and 2.2 mA ranges are increased by a factor of 1.3 plus 2 μA when supplied through 5725A terminals. Specifications are otherwise identical for all output locations.

Table 1-18. 5720A Series II AC Current Specifications: 95% Confidence Level

5720A 95%

95% Confidence Level

Range	Resolution	Frequency	Absolute Uncertainty ±5°C from calibration temperature For fields strengths >0.4 V/m but ≤3 V/m, add 1 % of range.				Relative Uncertainty ±1°C	
			24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		Hz	± (ppm output + nA)				± (ppm output + nA)	
220 µA	1 nA	10 - 20	210 + 16	230 + 16	240 + 16	250 + 16	210 + 16	230 + 16
		20 - 40	130 + 10	140 + 10	150 + 10	160 + 10	110 + 10	130 + 10
		40 - 1k	100 + 8	110 + 8	115 + 8	120 + 8	80 + 8	90 + 8
		1k - 5k	240 + 12	250 + 12	270 + 12	280 + 12	200 + 12	230 + 12
		5k - 10k	800 + 65	900 + 65	1000 + 65	1100 + 65	700 + 65	800 + 65
2.2 mA	10 nA	10 - 20	210 + 40	230 + 40	240 + 40	250 + 40	210 + 40	230 + 40
		20 - 40	140 + 35	140 + 35	150 + 35	160 + 35	110 + 35	130 + 35
		40 - 1k	100 + 35	110 + 35	115 + 35	120 + 35	80 + 35	90 + 35
		1k - 5k	170 + 110	180 + 110	190 + 110	200 + 110	200 + 110	230 + 110
		5k - 10k	800 + 650	900 + 650	1000 + 650	1100 + 650	700 + 650	800 + 650
22 mA	100 nA	10 - 20	210 + 400	230 + 400	240 + 400	250 + 400	210 + 400	230 + 400
		20 - 40	130 + 350	140 + 350	150 + 350	160 + 350	110 + 350	130 + 350
		40 - 1k	100 + 350	110 + 350	115 + 350	120 + 350	80 + 350	90 + 350
		1k - 5k	170 + 550	180 + 550	190 + 550	200 + 550	200 + 550	230 + 550
		5k - 10k	800 + 5000	900 + 5000	1000 + 5000	1100 + 5000	700 + 5000	800 + 5000
		Hz	± (ppm output + µA)				± (ppm output + µA)	
220 mA	1 µA	10 - 20	210 + 4	230 + 4	240 + 4	250 + 4	210 + 4	230 + 4
		20 - 40	130 + 3.5	140 + 3.5	150 + 3.5	160 + 3.5	110 + 3.5	130 + 3.5
		40 - 1k	100 + 2.5	110 + 2.5	115 + 2.5	120 + 2.5	80 + 2.5	90 + 2.5
		1k - 5k	170 + 3.5	180 + 3.5	190 + 3.5	200 + 3.5	200 + 3.5	230 + 3.5
		5k - 10k	800 + 10	900 + 10	1000 + 10	1100 + 10	700 + 10	800 + 10
2.2A	10 µA	20 - 1k	230 + 35	240 + 35	250 + 35	260 + 35	250 + 35	300 + 35
		1k - 5k	350 + 80	390 + 80	420 + 80	450 + 80	400 + 80	440 + 80
		5k - 10k	5000 + 160	6000 + 160	6500 + 160	7000 + 160	5000 + 160	6000 + 160
5725A Amplifier:								
11A	100 µA	40 - 1k	370 + 170	400 + 170	440 + 170	460 + 170	300 + 170	330 + 170
		1k - 5k	800 + 380	850 + 380	900 + 380	950 + 380	700 + 380	800 + 380
		5k - 10k	3000 + 750	3300 + 750	3500 + 750	3600 + 750	2800 + 750	3200 + 750

Note: Maximum output from the calibrator's terminals is 2.2A. Uncertainty specifications for 220 µA and 2.2 mA ranges are increased by 1.3 x plus 2 µA when supplied through 5725A terminals. Specifications are otherwise identical for all output locations.

Table 1-19. 5700A Series II AC Current Specifications: 99% Confidence Level

5700A
99%

99% Confidence Level

Range	Resolution	Frequency	Absolute Uncertainty ±5°C from calibration temperature For fields strengths >0.4 V/m but ≤3 V/m, add 1 % of range.				Relative Uncertainty ±1°C	
			24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		Hz	± (ppm output + nA)				± (ppm output + nA)	
220 μA	1 nA	10 - 20	650 + 30	700 + 30	750 + 30	800 + 30	450 + 30	500 + 30
		20 - 40	350 + 25	380 + 25	410 + 25	420 + 25	270 + 25	300 + 25
		40 - 1k	120 + 20	140 + 20	150 + 20	160 + 20	110 + 20	120 + 20
		1k - 5k	500 + 50	600 + 50	650 + 50	700 + 50	450 + 50	500 + 50
		5k - 10k	1500 + 100	1600 + 100	1700 + 100	1800 + 100	1400 + 100	1500 + 100
2.2 mA	10 nA	10 - 20	650 + 50	700 + 50	750 + 50	800 + 50	450 + 50	500 + 50
		20 - 40	350 + 40	380 + 40	410 + 40	420 + 40	270 + 40	300 + 40
		40 - 1k	120 + 40	140 + 40	150 + 40	160 + 40	110 + 40	120 + 40
		1k - 5k	500 + 500	600 + 500	650 + 500	700 + 500	450 + 500	500 + 500
		5k - 10k	1500 + 1000	1600 + 1000	1700 + 1000	1800 + 1000	1400 + 1000	1500 + 1000
22 mA	100 nA	10 - 20	650 + 500	700 + 500	750 + 500	800 + 500	450 + 500	500 + 500
		20 - 40	350 + 400	380 + 400	410 + 400	420 + 400	270 + 400	300 + 400
		40 - 1k	120 + 400	140 + 400	150 + 400	160 + 400	110 + 400	120 + 400
		1k - 5k	500 + 5000	600 + 5000	650 + 5000	700 + 5000	450 + 5000	500 + 5000
		5k - 10k	1500 + 10,000	1600 + 10,000	1700 + 10,000	1800 + 10,000	1400 + 10,000	1500 + 10,000
		Hz	± (ppm output + μA)				± (ppm output + μA)	
220 mA	1 μA	10 - 20	650 + 5	700 + 5	750 + 5	800 + 5	450 + 5	500 + 5
		20 - 40	350 + 4	380 + 4	410 + 4	420 + 4	280 + 4	300 + 4
		40 - 1k	120 + 4	150 + 4	170 + 4	180 + 4	110 + 4	130 + 4
		1k - 5k	500 + 50	600 + 50	650 + 50	700 + 50	450 + 50	500 + 50
		5k - 10k	1500 + 100	1600 + 100	1700 + 100	1800 + 100	1400 + 100	1500 + 100
2.2A	10 μA	20 - 1k	600 + 40	650 + 40	700 + 40	750 + 40	600 + 40	650 + 40
		1k - 5k	700 + 100	750 + 100	800 + 100	850 + 100	650 + 100	750 + 100
		5k - 10k	8000 + 200	9000 + 200	9500 + 200	10,000 + 200	7500 + 200	8500 + 200
5725A Amplifier:								
11A	100 μA	40 - 1k	370 + 170	400 + 170	440 + 170	460 + 170	300 + 170	330 + 170
		1k - 5k	800 + 380	850 + 380	900 + 380	950 + 380	700 + 380	800 + 380
		5k - 10k	3000 + 750	3300 + 750	3500 + 750	3600 + 750	2800 + 750	3200 + 750

Note: Maximum output from the calibrator's terminals is 2.2A. Uncertainty specifications for 220 μA and 2.2 mA ranges are increased by 1.3 x plus 2 μA when supplied through 5725A terminals. Specifications are otherwise identical for all output locations.

Table 1-20. 5700A Series II AC Current Specifications: 95% Confidence Level

5700A
95%

95% Confidence Level

Range	Resolution	Frequency	Absolute Uncertainty ±5°C from calibration temperature For fields strengths >0.4 V/m but ≤3 V/m, add 1 % of range.				Relative Uncertainty ±1°C	
			24 Hours	90 Days	180 Days	1 Year	24 Hours	90 Days
		Hz	± (ppm output + nA)				± (ppm output + nA)	
220 μA	1 nA	10 - 20	550 + 25	600 + 25	650 + 25	700 + 25	375 + 25	400 + 25
		20 - 40	280 + 20	310 + 20	330 + 20	350 + 20	220 + 20	250 + 20
		40 - 1k	100 + 16	120 + 16	130 + 16	140 + 16	90 + 16	100 + 16
		1k - 5k	400 + 40	500 + 40	550 + 40	600 + 40	375 + 40	400 + 40
		5k - 10k	1300 + 80	1400 + 80	1500 + 80	1600 + 80	1200 + 80	1200 +80
2.2 mA	10 nA	10 - 20	550 + 40	600 + 40	650 + 40	700 + 40	375 + 40	400 + 40
		20 - 40	280 + 35	310 + 35	330 + 35	350 + 35	220 + 35	250 + 35
		40 - 1k	100 + 35	120 + 35	130 + 35	140 + 35	90 + 35	100 + 35
		1k - 5k	400 + 400	500 + 400	550 + 400	600 + 400	375 + 400	400 + 400
		5k - 10k	1300 + 800	1400 + 800	1500 + 800	1600 + 800	1200 + 800	1200 + 800
22 mA	100 nA	10 - 20	550 + 400	600 + 400	650 + 400	700 + 400	375 + 400	400 + 400
		20 - 40	280 + 350	310 + 350	330 + 350	350 + 350	220 + 350	250 + 350
		40 - 1k	100 + 350	120 + 350	130 + 350	140 + 350	90 + 350	100 + 350
		1k - 5k	400 + 4000	500 + 4000	550 + 4000	600 + 4000	375 + 4000	400 + 4000
		5k - 10k	1300 + 8000	1400 + 8000	1500 + 8000	1600 + 8000	1200 + 8000	1200 + 8000
		Hz	± (ppm output + μA)				± (ppm output + μA)	
220 mA	1 μA	10 - 20	550 + 4	600 + 4	650 + 4	700 + 4	375 + 4	400 + 4
		20 - 40	280 + 3.5	310 + 3.5	330 + 3.5	350 + 3.5	220 + 3.5	250 + 3.5
		40 - 1k	100 + 3.5	120 + 3.5	130 + 3.5	140 + 3.5	90 + 3.5	100 + 3.5
		1k - 5k	400 + 40	500 + 40	550 + 40	600 + 40	375 + 40	400 + 40
		5k - 10k	1300 + 80	1400 + 80	1500 + 80	1600 + 80	1200 + 80	1200 + 80
2.2A	10 μA	20 - 1k	500 + 35	550 + 35	600 + 35	650 + 35	500 + 35	550 + 35
		1k - 5k	600 + 80	650 + 80	700 + 80	750 + 80	550 + 80	650 + 80
		5k - 10k	6500 + 160	7500 + 160	8000 + 1600	8500 + 160	6000 + 160	7000 + 160
5725A Amplifier:								
11A	100 μA	40 - 1k	370 + 170	400 + 170	440 + 170	460 + 170	300 + 170	330 + 170
		1k - 5k	800 + 380	850 + 380	900 + 380	950 + 380	700 + 380	800 + 380
		5k - 10k	3000 + 750	3300 + 750	3500 + 750	3600 + 750	2800 + 750	3200 + 750

Note: Maximum output from the calibrator's terminals is 2.2A. Uncertainty specifications for 220 μA and 2.2 mA ranges are increased by a factor of 1.3 plus 2 μA when supplied through 5725A terminals. Specifications are otherwise identical for all output locations.

Table 1-21. AC Current Secondary Performance Specifications and Operating Characteristics

Range	Frequency	Stability ±1°C [Note 1] 24 Hours	Temperature Coefficient [Note 2] 10°-40°C	Temperature Coefficient [Note 2] 0°-10°C and 40°-50°C	Compliance Limits	Maximum Resistive Load For Full Accuracy [Note 3]	Noise and Distortion Bandwidth 10 Hz-50 kHz <0.5V Burden
	Hz	± (ppm output + nA)	± (ppm output + nA)/°C		V rms	Ω	± (% output + µA)
220 µA	10 - 20	150 + 5	50 + 5	50 + 5	7	2k	0.05 + 0.1
	20 - 40	80 + 5	20 + 5	20 + 5			0.05 + 0.1
	40 - 1k	30 + 3	4 + 0.5	10 + 0.5			0.05 + 0.1
	1k - 5k	50 + 20	10 + 1	20 + 1			0.25 + 0.5
	5k - 10k	400 + 100	20 + 100	20 + 100			0.5 + 1
2.2 mA	10 - 20	150 + 5	50 + 5	50 + 5	7	500	0.05 + 0.1
	20 - 40	80 + 5	20 + 4	20 + 4			0.05 + 0.1
	40 - 1k	30 + 3	4 + 1	10 + 2			0.05 + 0.1
	1k - 5k	50 + 20	10 + 100	20 + 100			0.25 + 0.5
	5k - 10k	400 + 100	50 + 400	50 + 400			0.5 + 1
22 mA	10 - 20	150 + 50	50 + 10	50 + 10	7	150	0.05 + 0.1
	20 - 40	80 + 50	20 + 10	20 + 10			0.05 + 0.1
	40 - 1k	30 + 30	4 + 10	10 + 20			0.05 + 0.1
	1k - 5k	50 + 500	10 + 500	20 + 400			0.25 + 0.5
	5k - 10k	400 + 1000	50 + 1000	50 + 1000			0.5 + 1
	Hz	± (ppmutput + µA)	± (ppm output + µA)/°C				
220 mA	10 - 20	150 + 0.5	50 + 0.05	50 + 0.05	7	15	0.05 + 10
	20 - 40	80 + 0.5	20 + 0.05	20 + 0.05			0.05 + 10
	40 - 1k	30 + 0.3	4 + 0.1	10 + 0.1			0.05 + 10
	1k - 5k	50 + 3	10 + 2	20 + 2			0.25 + 50
	5k - 10k	400 + 5	50 + 5	50 + 5			0.5 + 100
2.2A	20 - 1k	50 + 5	4 + 1	10 + 1	1.4 [Note 4]	0.5	0.5 + 100
	1k - 5k	80 + 20	10 + 5	20 + 5			0.3 + 500
	5k - 10k	800 + 50	50 + 10	50 + 10			1 + 1 mA
5725A Amplifier:							± (% output)
11A	40 - 1k	75 + 100	20 + 75	30 + 75	3	3	[Note 5]
	1k - 5k	100 + 150	40 + 75	50 + 75			
	5k - 10k	200 + 300	100 + 75	100 + 75			

Notes:

Maximum output from 5720A terminals is 2.2A. Uncertainty specifications for 220 µA and 2.2 mA ranges are increased by a factor of 1.3, plus 2 µA when supplied through 5725A terminals. Specifications are otherwise identical for all output locations.

1. Stability specifications are included in the Absolute Uncertainty values for the primary specifications.
2. Temperature coefficient is an adder to uncertainty specifications that does not apply unless operating more than ±5°C from calibration temperature.
3. For larger resistive loads multiply uncertainty specifications by: $\left(\frac{\text{actual load}}{\text{maximum load for full accuracy}}\right)^2$
4. 1.5V compliance limit above 1A. 5725A Amplifier may be used in range-lock mode down to 1A.
5. For resistive loads within rated compliance voltage limits.

Minimum output: 9 µA for 220 µA range, 10% on all other ranges. 1A minimum for 5725A.

Inductive load limits: 400 µH (5700A/5720A, or 5725A). 20 µH for 5700A/5720A output >1A.

Power factors: 5700A/5720A, 0.9 to 1; 5725A, 0.1 to 1. Subject to compliance voltage limits.

Frequency:

Range (Hz): 10.000-11.999, 12.00-119.99, 120.0-1199.9, 1.200k-10.000k

Uncertainty: ±0.01%

Resolution: 11,999 counts

Settling time to full accuracy: 5 seconds for 5700A/5720A ranges; 6 seconds for 5725A 11A range; +1 second for amplitude or frequency range change.

Overshoot: <10%

Wideband AC Voltage (Option 5700A-03) Specifications *1-34.*

Table 1-22. Wideband AC Voltage (Option 5700-03) Specifications

Specifications apply to the end of the cable and 50Ω termination used for calibration

Range		Resolution	Absolute Uncertainty ±5°C from calibration temperature 30 Hz-500 kHz			
Volts	dBm		24 Hours	90 Days	180 Days	1 Year
			± (% output + µV)			
1.1 mV	-46	10 nV	0.4 + 0.4	0.5 + 0.4	0.6 + 0.4	0.8 + 2
3 mV	-37	10 nV	0.4 + 1	0.45 + 1	0.5 + 1	0.7 + 3
11 mV	-26	100 nV	0.2 + 4	0.35 + 4	0.5 + 4	0.7 + 8
33 mV	-17	100 nV	0.2 + 10	0.3 + 10	0.45 + 10	0.6 + 16
110 mV	-6.2	1 µV	0.2 + 40	0.3 + 40	0.45 + 40	0.6 + 40
330 mV	+3.4	1 µV	2 + 100	25 + 100	0.35 + 100	0.5 + 100
1.1V	+14	10 µV	0.2 + 400	0.25 + 400	0.35 + 400	0.5 + 400
3.5V	+24	10 µV	15 + 500	0.2 + 500	0.3 + 500	0.4 + 500

Frequency	Frequency Resolution	Amplitude Flatness, 1 kHz Reference Voltage Range			Temperature Coefficient	Settling Time To Full Accuracy	Harmonic Distortion
		1.1 mV	3 mV	>3 mV			
Hz	Hz	±%			±ppm/°C	Seconds	dB
10 - 30	0.01	0.3	0.3	0.3	100	7	-40
30 - 120	0.01	0.1	0.1	0.1	100	7	-40
120 - 1.2k	0.1	0.1	0.1	0.1	100	5	-40
1.2k - 12k	1	0.1	0.1	0.1	100	5	-40
12k - 120k	10	0.1	0.1	0.1	100	5	-40
120k - 1.2M	100	0.2 + 3 µV	0.1 + 3 µV	0.1 + 3 µV	100	5	-40
1.2M - 2M	100k	0.2 + 3 µV	0.1 + 3 µV	0.1 + 3 µV	100	0.5	-40
2M - 10M	100k	0.4 + 3 µV	0.3 + 3 µV	0.2 + 3 µV	100	0.5	-40
10M - 20M	1M	0.6 + 3 µV	0.5 + 3 µV	0.4 + 3 µV	150	0.5	-34
20M - 30M	1M	10.5 + 15 µV	10.5 + 3 µV	1 + 3 µV	300	0.5	-34

Additional Operating Information:

dBm reference = 50Ω

Range boundaries are at voltage points, dBm levels are approximate.

$\text{dBm} = 10 \log \left(\frac{\text{Power}}{1\ \text{mW}} \right)$; 0.22361V across 50Ω = 1 mW or 0 dBm

Minimum output: 300 µV (-57 dBm)

Frequency uncertainty: ±0.01%

Frequency resolution: 11,999 counts to 1.1999 MHz, 119 counts to 30 MHz.

Overload protection: A short circuit on the wideband output will not result in damage. After settling time, normal operation is restored upon removal.

General Specifications *1-35.*

Warm-Up Time: Twice the time since last warmed up, to a maximum of 30 minutes.

System installation: Rear output configuration and rack- mount kit available.

Standard interfaces: IEEE-488, RS-232, 5725A, 5205A or 5215A, 5220A, phase lock in (BNC), phase reference out (BNC).

Temperature performance: Operating: 0°C to 50°C. Calibration: 15°C to 35°C. Storage: -40°C to 75°C; DC Zeros calibration required every 30 days.

Relative humidity: Operating: <80% to 30°C, <70% to 40°C, <40% to 50°C. Storage: <95%, non-condensing. A power stabilization period of four days may be required after extended storage at high temperature and humidity.

Safety: Designed to comply with UL3111; EN61010; CSA C22.2 No. 1010; ANSI/ISA S82.01-1994

Guard isolation: 20V

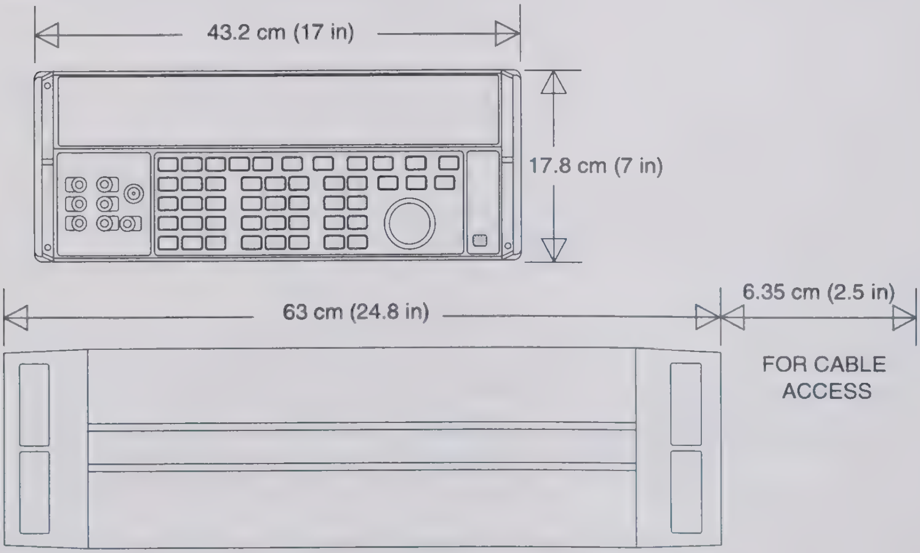
EMI/RFI: Designed to comply with FCC Rules Part 15, Subpart B, Class B; EN50081-1, EN50082-1

Line Power: 47 to 63 Hz; ±10% allowed about selectable nominal line voltage: 100V, 110V, 115V, 120V, 200V, 220V, 230V, 240V. Maximum power: 5700A/5720A, 300VA; 5725A, 750VA.

Size:
5700A/5720A: Height 17.8 cm (7 in), standard rack increment, plus 1.5 cm (0.6 in) for feet; Width 43.2 cm (17 in), standard rack width; Depth 63.0 cm (24.8 in), overall; 57.8 cm (22.7 in), rack depth.

5725A: Height 13.3 cm, (5.25 in); Width and depth same as 5700A/5720A. Both units project 5.1 cm, (2 in) from rack front.

Weight: 5700A/5720A: 27kg (62 lbs); 5725A: 32kg (70 lbs).



Auxiliary Amplifier Specifications *1-36.*

For complete specifications, see the 5205A and 5220A Operators Manuals.

5205A (220V - 1100V ac, 0V - 1100V dc)

Overshoot: < 10%

Distortion (bandwidth 10 Hz - 1 MHz):

10 Hz - 20 kHz	0.07%
20 kHz - 50 kHz	0.2%
50 kHz - 100 kHz	0.25%

Frequency (Hz)	90 Day Accuracy at 23° ±5°C ± (% output + % range)	Temperature Coefficient for 0°-18°C and 28°-50°C ± (ppm output + ppm range)/°C
dc	0.05 + 0.005	15 + 3
10 - 40	0.15 + 0.005	45 + 3
40 - 20k	0.04 + 0.004	15 + 3
20k - 50k	0.08 + 0.006	50 + 10
50k - 100k	0.1 + 0.01	70 + 20

5220A (AC Current, 180-day specifications):

Accuracy:

20 Hz - 1 kHz	0.07% + 1 mA
1 kHz - 5 kHz	(0.07% + 1mA) x frequency in kHz

Temperature Coefficient (0° - 18°C and 28° - 50°C): (0.003% + 100 μA)/°C

Distortion (bandwidth 300 kHz):

20 Hz - 1 kHz	0.1% + 1 mA
1 kHz - 5 kHz	(0.1% + 1 mA) x frequency in kHz

Note: 5700A/5720A combined with 5220A is not specified for inductive loads.

Chapter 2
Theory of Operation

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Introduction 2-1.

This section provides theory of operation in increasing level of detail. The calibrator is first broadly defined in terms of digital functions (relating to the Digital Motherboard assembly) and analog functions (relating to the Analog Motherboard assembly). The interrelationship of these two areas is then explored in discussions of each output function. Finally, the overall picture is rounded out with a discussion of system interconnections.

Most of this section is devoted to detailed circuit descriptions, first of in the digital (unguarded) section, then in the analog (guarded) section.

Calibrator Overview 2-2.

Figures 2-1, 2-2, and 2-3 comprise the block diagram of the Calibrator. These figures are presented further on in the Analog Section Overview and the Digital Section Overview.

The Calibrator is configured internally as an automated calibration system with process controls and consistent procedures. Internal microprocessors control all functions and monitor performance, using a switching matrix to route signals between modules. Complete automatic internal diagnostics, both analog and digital, confirm operational integrity.

The heart of the measurement system is a 5 1/2-digit adc (analog-to-digital converter), which is used in a differential mode with the Calibrator dac. (The dac is described next under "Internal References.")

Internal References 2-3.

The major references that form the basis of the Calibrator's accuracy are the hybrid reference amplifiers, patented Fluke solid-state thermal rms sensors, an extremely linear dac, and two internal precision resistors.

Hybrid Reference Amplifiers 2-4.

A precision source can only be as accurate as its internal references, so the dc voltage reference for the Calibrator was chosen with extreme care. Years of data collection have proven the ovenized reference amplifier to be the best reference device available for modern, ultra-stable voltage standards.

In a microprocessor-controlled precision instrument such as the 5700A/5720A Series II, the important characteristics of its dc voltage references are not the accuracy of the value of the references, but rather their freedom from drift and hysteresis. (Hysteresis is the condition of stabilizing at a different value after being turned off then on again.) The 5700A/5720A Series II hybrid reference amplifiers excel in both freedom from drift and absence of hysteresis.

Fluke Thermal Sensor (FTS) 2-5.

Thermal rms sensors, or ac converters, convert ac voltage to dc voltage with great accuracy. These devices sense true rms voltage by measuring the heat generated by a voltage through a known resistance.

Conventional thermal voltage converters suffer from two main sources of error. First, they exhibit frequency response errors caused by component reactance. Second, they have a poor signal-to-noise ratio because they operate at the millivolt level. The FTS has a full-scale input and output of 2V and a flat frequency response.

After initial functional verification of the Fluke Thermal Sensors, their characteristics only change by less than 1/10th of the allowed ac/dc error per year. External calibration of the ac voltage function of the Calibrator consists of verifying that the Calibrator meets its specifications.

Digital-to-Analog Converter (DAC) 2-6.

A patented 26-bit dac is used in the calibrator as a programmable voltage divider. The dac is a pulse-width modulated (pwm) type with linearity better than 1 ppm (part-per-million) from 1/10th scale to full scale.

Digital Section Overview 2-7.

The unguarded Digital Section contains the CPU assembly (A20), Digital Power Supply assembly (A19), Front Panel assembly (A2), Keyboard assembly (A1), and the unguarded portion of the Rear Panel assembly (A21). Figure 2-1 is a block diagram of the digital section of the Calibrator.

Power for the digital assemblies and the cooling fans is supplied by the Digital Power Supply assembly.

The CPU (central processing unit) assembly is a single-board computer based on the 68HC000 microprocessor. It controls local and remote interfaces, as well as serial communications over a fiber-optic link to the crossing portion of the Regulator/Guard Crossing assembly (A17). The guard crossing controls the guarded analog circuitry.

A Keyboard assembly provides the user with front-panel control of the Calibrator. It contains four LED's, a rotary edit knob, and a forty-five key keypad. It connects to the Front Panel assembly via a cable.

The Front Panel assembly provides information to the user on an Output Display and a Control Display. The Front Panel also contains circuitry that scans the keyboard and encodes key data for the CPU.

The Rear Panel assembly includes digital interfaces for the following:

- IEEE-488 bus connection
- RS-232-C DTE serial port
- Four auxiliary amplifiers: the 5725A, 5205A, 5215A, and 5220A

Analog Section Overview 2-8.

The guarded analog section contains the following assemblies:

- Wideband Output (A5) (Part of Option -03)
- Wideband Oscillator (A6) (Part of Option -03)
- Current/Hi-Res (A7)
- Switch Matrix (A8)
- Ohms Cal (A9)
- Ohms (A10)
- DAC (A11)
- Oscillator Control (A12)
- Oscillator Output (A13)
- High Voltage Control (A14)
- High Voltage/High Current (A15)
- Power Amplifier (A16)
- Regulator/Guard Crossing (A17)
- Filter/PA Supply (A18)

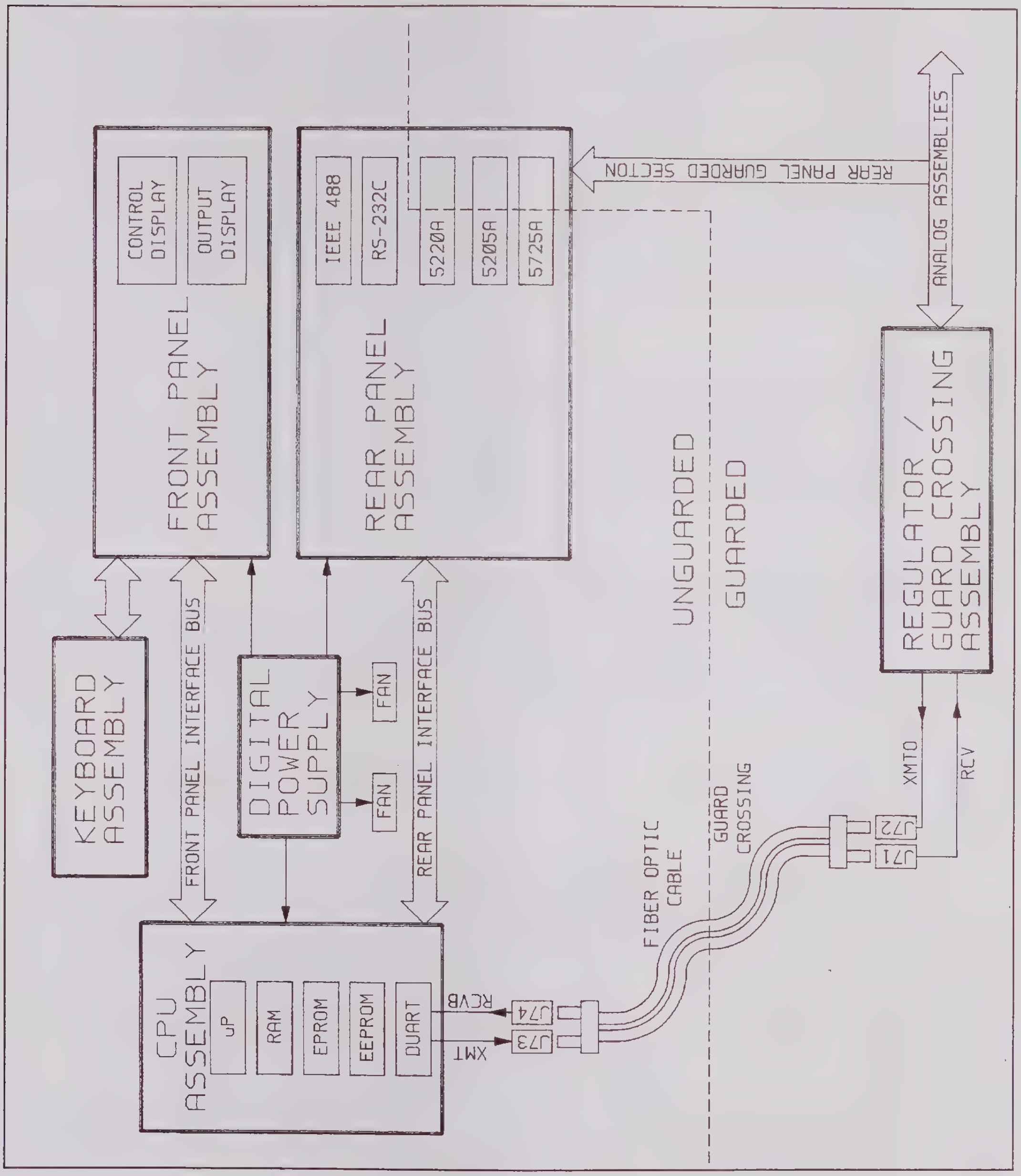


Figure 2-1. Digital Section Block Diagram

These analog assemblies are interfaced to the Analog Motherboard assembly (A3). The guarded digital bus generated by the guard crossing portion of the Regulator/Guard Crossing assembly controls all analog assemblies except the Filter/PA Supply. The Guard Crossing interfaces with the unguarded CPU assembly via a fiber-optic link. The Transformer assembly, along with the filter portion of the Filter/PA Supply assembly and the regulator portion of the Regulator/Guard Crossing assembly, create the system power supply for all the analog assemblies. The Power Amplifier Supply portion of the Filter/PA Supply assembly provides the high voltage power supplies required by the Power Amplifier assembly. The amplitudes of these high voltage supplies are controlled by circuitry contained on the Power Amplifier assembly.

Figures 2-2 and 2-3 are block diagrams for the analog section of the Calibrator.

Functional Description Presented by Output Function 2-9.

This part of the theory section presents Calibrator operation from the perspective of each output function. It describes which assemblies come into play, and how they interact. It does not provide a detailed circuit description. Refer to the individual assembly theories further on in this section for detailed circuit descriptions.

DC Voltage Functional Description 2-10.

The DAC assembly (A11) provides a stable dc voltage and is the basic building block of the Calibrator. DC voltages are generated in six ranges:

- 220 mV
- 2.2V
- 11V
- 22V
- 220V
- 1100V

The 11V and 22V ranges are generated by the DAC assembly, with its output, DAC OUT HI and DAC SENSE HI routed to the Switch Matrix assembly, where relays connect it to INT OUT HI and INT SENSE HI. Lines INT OUT HI and INT SENSE HI connect to the Calibrator binding posts by relays on the Analog Motherboard assembly (A3).

The 2.2V range is created on the Switch Matrix assembly by resistively dividing by five the 11V range from the DAC assembly. Relays on the Switch Matrix and Analog Motherboard route the 2.2V range output to the Calibrator binding posts.

The 220 mV range is an extension of the 2.2V range. The Switch Matrix assembly resistively divides by ten the 2.2V range to create the 220 mV range. Relays on the Switch Matrix and Analog Motherboard route the 220 mV range output to the front panel binding posts.

The 220V range is generated by the DAC and Power Amplifier assemblies. The Power Amplifier amplifies the 11V range of the DAC assembly by a gain of -20 to create the 220V range. The output of the Power Amplifier is routed to the High Voltage Control assembly (A14), where a relay connects it to PA OUT DC. Line PA OUT DC is routed to the binding posts via relays on the Switch Matrix and Analog Motherboard.

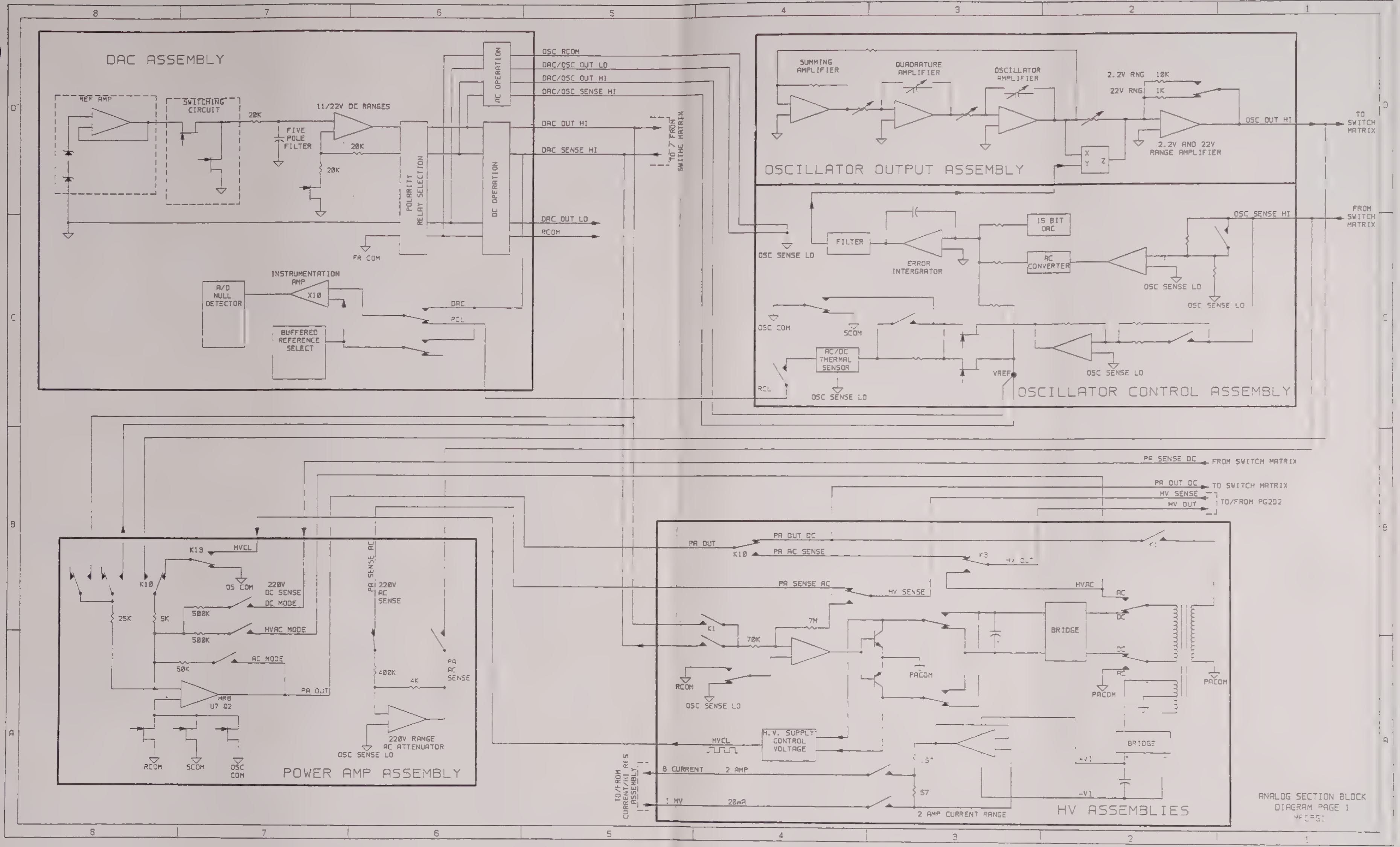


Figure 2-2. Analog Section Block Diagram, Part 1

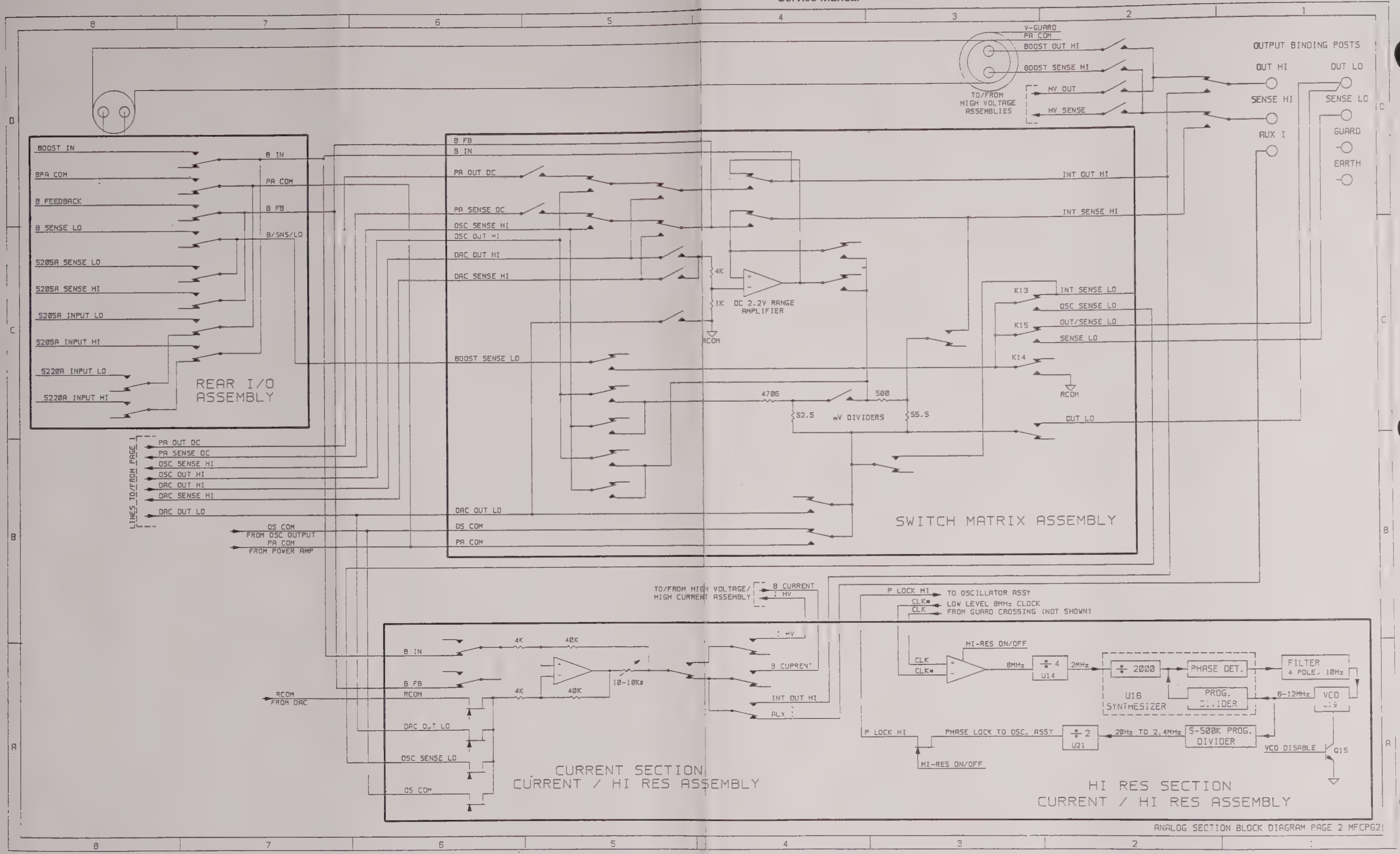


Figure 2-3. Analog Section Block Diagram, Part 2

The 1100V range is generated by the High Voltage/High Current assembly (A15) operating in conjunction with the Power Amplifier assembly and the High Voltage Control assembly. The 11V range of the DAC assembly is routed to the High Voltage/High Current assembly which amplifies by a gain of -100 to create the 1100V range. Basically the high voltage output is obtained by rectifying and filtering a high voltage ac signal generated by the High Voltage Control assembly operating in conjunction with the Power Amplifier assembly.

AC Voltage Functional Description 2-11.

The Oscillator Output assembly (A13) is the ac signal source for the Calibrator. The Oscillator Control assembly (A12), controls the amplitude of this ac signal by comparing it with the accurate dc voltage from the DAC assembly and making amplitude corrections via the OSC CONT line. The frequency of oscillation is phase locked to either the high resolution oscillator on the Current/Hi-Res (A7) assembly or an external signal connected to the PHASE LOCK IN connector on the rear panel. AC voltages are generated in the following ranges:

- 2.2 mV
- 22 mV
- 220 mV
- 2.2V
- 11V
- 22V
- 220V
- 1100V

The 2.2V and 22V ranges are generated by the Oscillator Output assembly and routed to the Calibrator binding posts via relays on the Switch Matrix (A8) and Analog Motherboard assemblies.

The 220 mV range is generated on the Switch Matrix assembly, which resistively divides by ten the 2.2V range of the Oscillator Output assembly. Relays on the Switch Matrix and Analog Motherboard route the 220 mV range to the Calibrator binding posts.

The 2.2 mV and 22 mV ranges are generated on the Switch Matrix assembly. In this mode, the Switch Matrix resistively divides the 2.2V range or the 22V range by 1000 to create the 2.2 mV and 22 mV ranges respectively. Relays on the Switch Matrix and Analog Motherboard route these ranges to the Calibrator binding posts.

The 220V range is generated on the Power Amplifier assembly. In this mode, the Power Amplifier is set for a nominal gain of -10 to amplify the 22V range from the Oscillator Output to the 220V range. The 220V ac range from the Power Amplifier is routed to the Calibrator binding posts by relays on the High Voltage Control assembly and the Analog Motherboard.

The 1100V range is generated by the High Voltage Control assembly operating in conjunction with the Power Amplifier assembly. In this mode, the 22V range from the Oscillator Output is amplified by the Power Amplifier and High Voltage Control assemblies, which create an amplifier with a nominal gain of -100. Relays on the High Voltage Control and Analog Motherboard assemblies route the 1100V ac range to the Calibrator binding posts.

Wideband AC V Functional Description (Option -03) 2-12.

The Wideband AC Voltage module (Option -03) consists of the Wideband Oscillator assembly (A6) and the Wideband Output assembly (A5). There are two wideband frequency ranges:

- 10 Hz to 1.1 MHz
- 1.2 MHz to 30 MHz

During operation between 10 Hz and 1.1 MHz, output from the Oscillator Output assembly is routed to the Wideband Output assembly where it is amplified and attenuated to achieve the specified amplitude range. The output is connected to the Calibrator front panel WIDEBAND connector. Operation between 1.2 MHz and 30 MHz works the same way, except the input to the Wideband Output assembly is the ac signal from the Wideband Oscillator assembly.

DC Current Functional Description 2-13.

DC current is generated in five ranges:

- 20 µA - 220 µA
- 220 µA - 2.2 mA
- 2.2 mA - 22 mA
- 22 mA - 220 mA
- 2.2A

All current ranges except 2.2A are generated by the current portion of the Current/Hi-Res assembly. These currents are created by connecting the output of the DAC assembly, set to the 22V range, to the input of the Current assembly. The Current assembly uses this dc voltage to create the output current. The current output can be connected to the AUX CURRENT OUTPUT binding post by relays on the Current assembly, to the OUTPUT HI binding post by relays on the Current, Switch Matrix, and Analog Motherboard assemblies, or to the 5725A via the B-CUR line by relays on the Analog Motherboard assembly and Rear Panel assembly.

The 2.2A range is an extension of the 22 mA range. The 22 mA range output from the Current assembly is amplified by a gain of 100 by the High Voltage/High Current assembly operating in conjunction with the Power Amp assembly and the High Voltage Control assembly. The 2.2A current range is routed back to the Current assembly where it is connected to either the AUX CURRENT OUTPUT binding post, the OUTPUT HI binding post, or the 5725A in the same manner as the lower current ranges.

AC Current Functional Description 2-14.

AC current is created in the same manner as dc current, except the input to the Current assembly is the ac voltage from the Oscillator Output assembly set to the 22V range. The switching between ac and dc is carried out on the Switch Matrix, Oscillator Control, Oscillator Output, and DAC assemblies.

Ohms Functional Description 2-15.

Two assemblies function as one to supply the fixed values of resistance:

- Ohms Main assembly (A10)
- Ohms Cal assembly (A9)

All of the resistance values except the 1Ω, 1.9Ω, and short are physically located on the Ohms Main assembly. The 1Ω, 1.9Ω, and short are physically located on the Ohms Cal assembly. The desired resistance is selected by relays on these Ohms assemblies and is connected to the Calibrator binding posts by relays on the Analog Motherboard. The Ohms Cal assembly also contains the appropriate circuitry to enable the Calibrator to perform resistance calibration. Once calibrated, the Calibrator output display shows the true value of the resistance selected, not the nominal (e.g., 10.00031 kΩ, not 10 kΩ).

Four ohms measurement modes are available. For the two-wire configuration, measurement with or without lead-drop compensation sensed at the binding posts of the UUT (using the SENSE binding posts and another set of leads), or at the ends of its test leads is available for 19 kΩ and below. Four-wire configuration is available for all but the 100 MΩ value.

System Interconnect Detailed Circuit Description 2-16.

The motherboard assembly contains the Digital Motherboard assembly (A4), and the Analog Motherboard assembly (A3). These two Motherboards are mechanically fastened together with screws. They are electrically connected by connectors P81 and P82 on the Digital Motherboard and connectors J81 and J82 on the Analog Motherboard. AC voltage taps from the Transformer assembly (A22) are connected to the Analog Motherboard through these connectors. Refer to Figure 2-4 for an overview of system interconnections. Figure 2-4 continues on the reverse side, showing system grounds.

Digital Motherboard Assembly (A4) 2-17.

The Digital Motherboard contains the line-select switches, line fuse, power switch, a fiber-optic transmitter (J73), and a fiber-optic receiver (J74). It also contains connectors for the Transformer assembly (A22), Digital Power Supply assembly (A19), CPU assembly (A20), Front Panel assembly (A2), Rear Panel assembly (A21), and the two 24V dc fans mounted in the chassis.

The fiber-optic receiver and transmitter provide the serial communication link between the CPU on the unguarded Digital Motherboard and the Regulator/Guard Crossing on the guarded Analog Motherboard.

Transformer Assembly (A22) 2-18.

The Transformer assembly receives ac line inputs routed through the A4 Digital Motherboard. This assembly supplies outputs throughout the Calibrator, all of which are routed through the A4 Digital Motherboard.

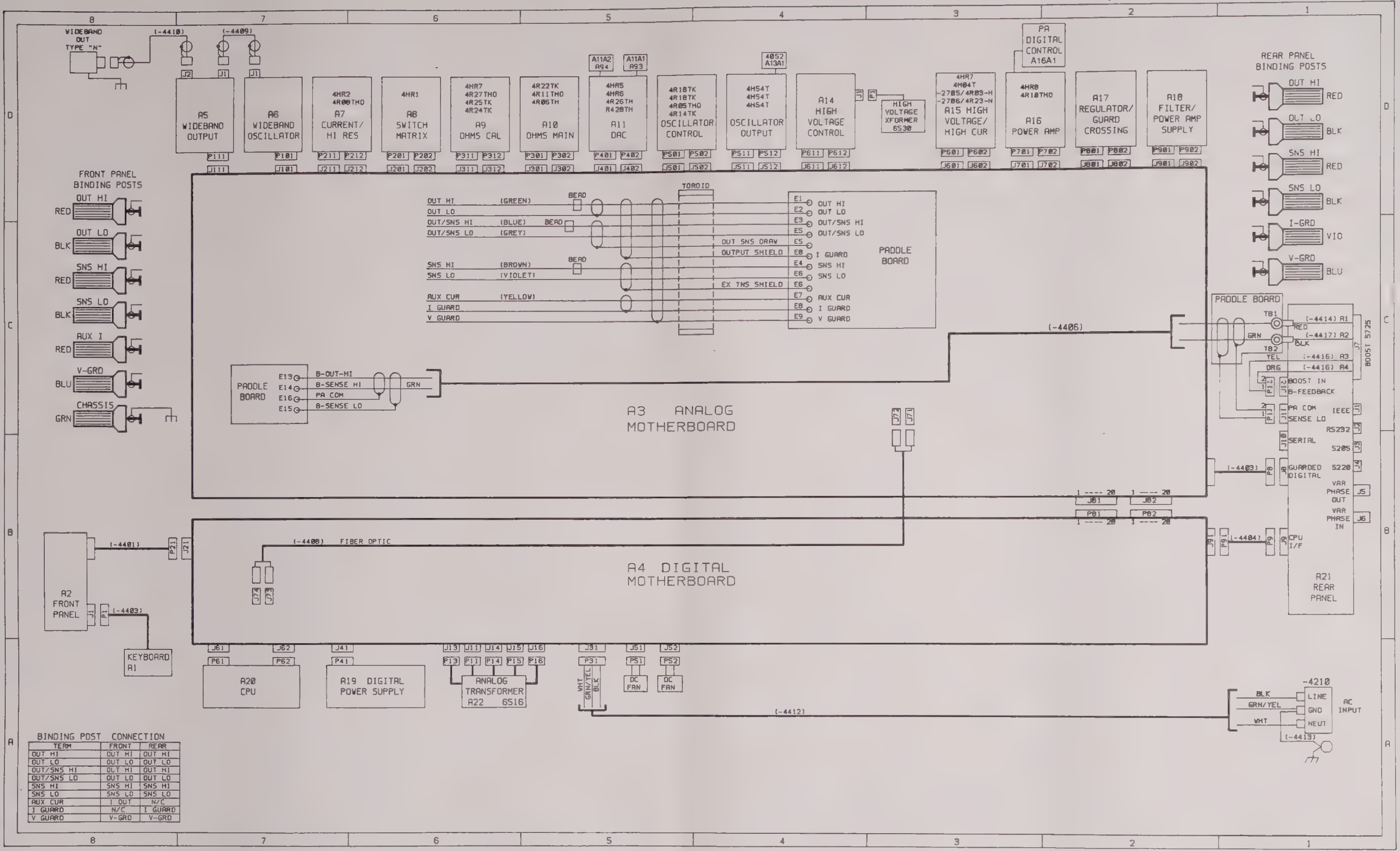
The Transformer assembly, the filter portion of the Filter/PA Supply assembly (A18), and the regulator portion of the Regulator/Guard Crossing assembly (A17) create the system power supply for all analog assemblies. The Transformer assembly also supplies ac voltages to the Digital Power Supply assembly which generates five regulated dc voltages for use by the CPU, Front Panel assembly, Rear Panel assembly, and the cooling fans.

Analog Motherboard Assembly (A3) 2-19.

The Analog Motherboard contains the connectors for all assemblies in the guarded section of the calibrator. The Analog Motherboard also contains 13 relays, a fiber-optic transmitter, a fiber-optic receiver, a cable for binding post connections, and two cables for the interface to the Rear Panel assembly. Table 2-1 lists Analog Motherboard

The fiber-optic transmitter (J72) and the fiber-optic receiver (J71) provide the serial communication link between the Regulator/Guard Crossing assembly and the CPU assembly on the unguarded Digital Motherboard.

Control lines for relays K1-K10 and K13 on the Analog Motherboard assembly are generated on the Switch Matrix (A8) assembly. Control line RLY11*, which controls relay K11, is generated on the Current/Hi-Res assembly (A7). Control line RLY12*, which controls relay K12, is generated on the Rear Panel assembly (A21).



BINDING POST CONNECTION

TERM	FRONT	REAR
OUT HI	OUT HI	OUT HI
OUT LO	OUT LO	OUT LO
OUT/SNS HI	OUT HI	OUT HI
OUT/SNS LO	OUT LO	OUT LO
SNS HI	SNS HI	SNS HI
SNS LO	SNS LO	SNS LO
AUX CUR	I OUT	N/C
I GUARD	N/C	I GUARD
V GUARD	V-GRD	V-GRD

Figure 2-4. System Interconnections

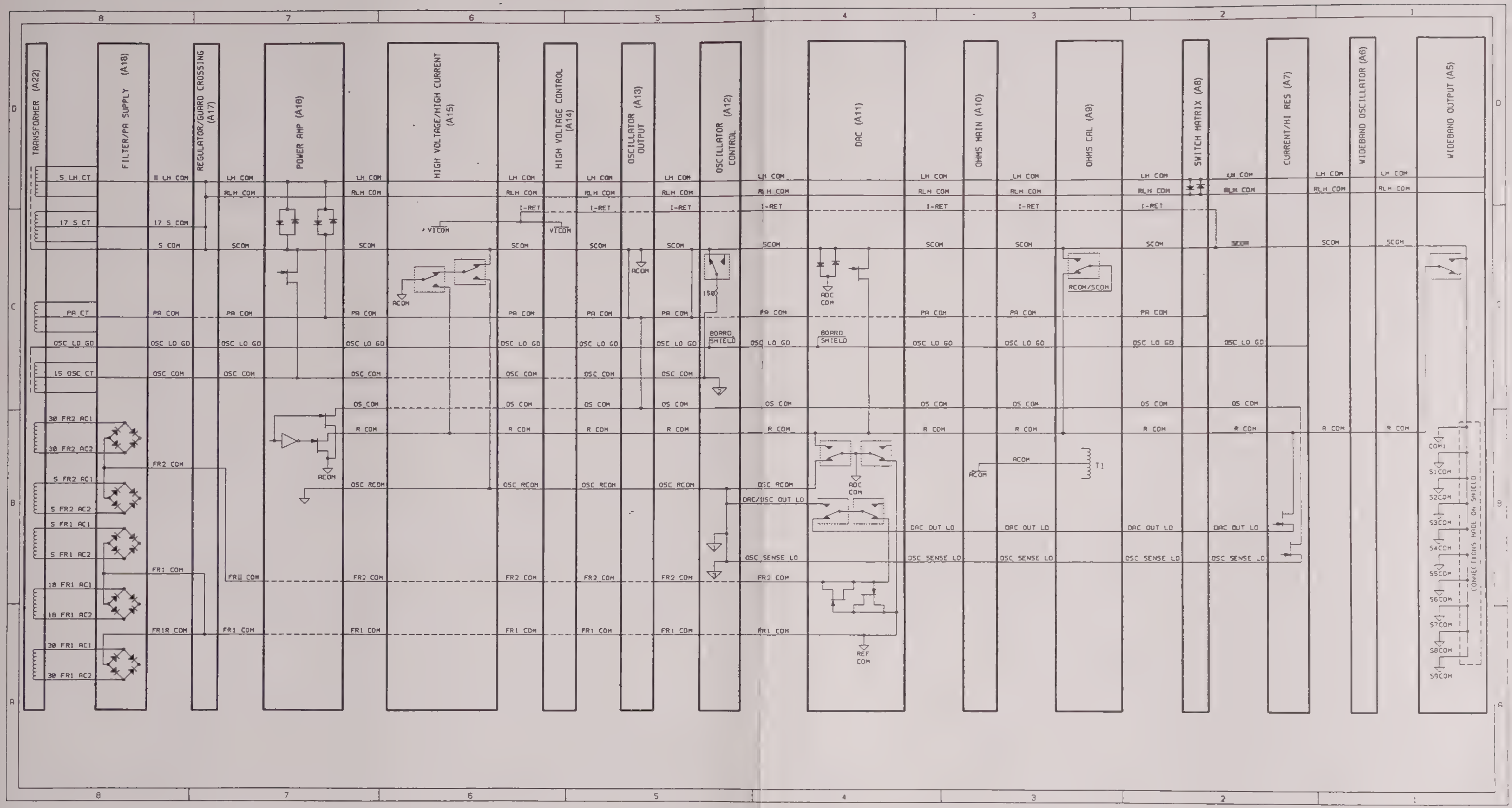


Figure 2-4. System Interconnections (cont)

Table 2-1. Analog Motherboard Connectors

Motherboard Connector	Connected to Assembly
J101	Wideband Oscillator Assembly (A6)
J111	Wideband Output Assembly (A5)
J201 and J202	Switch Matrix Assembly (A8)
J211 and J212	Current/Hi-Res Assembly (A7)
J301 and J302	Ohms Main Assembly (A10)
J311 and J312	Ohms Cal Assembly (A9)
J401 and J402	DAC Assembly (A11)
J501 and J502	Oscillator Control Assembly (A12)
J511 and J512	Oscillator Output Assembly (A13)
J601 and J602	High Voltage/High Current Assembly (A15)
J611 and J612	High Voltage Control Assembly (A14)
J701 and J702	Power Amplifier Assembly (A16)
J801 and J802	Regulator/Guard Crossing Assembly (A17)
J901 and J902	Filter/PA Supply Assembly (A18)

Line INT OUT HI is the calibrator output for ac voltage operation in the 22V range and below, dc voltage operation in the 220V range and below, all resistance functions, and all ac/dc current ranges. Relays on the Current assembly route the current output to the AUX CURRENT OUTPUT binding post via the I OUT line if so selected by the operator. INT SENSE HI is the sense high path during these modes of operation. INT OUT HI is connected to the OUTPUT HI binding post through relay K1. INT SENSE HI is connected to the SENSE HI or OUTPUT HI binding post through relays K2 and K3.

Line HV OUT is the calibrator output for dc voltage operation in the 1100V range, and ac voltage operation in the 220V and 1100V ranges. Line HV SENSE is the sense high path during these modes of operation. HV OUT is connected to the OUT HI binding post through relays K9 and K1. HV SENSE is connected to the SENSE HI or OUTPUT HI binding post through relays K10, K2, and K3.

The 5725A Amplifier output is B OUT HI and the sense high path is B SNS HI. When the 5725A is active, B OUT HI is connected to the OUT HI binding post through relays K4 and K1. When the 5725A Amplifier is inactive, B OUT HI is connected to GUARD CHASSIS by relay K12. Line B SNS HI is tied to B OUT HI through diode clamps CR1 and CR2 and is connected to the SENSE HI or OUTPUT HI binding post through relays K5, K2, and K3.

The cable from the motherboard to the binding posts consists of six insulated wires and six shields, each with its own drain wire. The OUT HI line, SENSE HI line, OUT/SENSE HI line and AUX CURRENT line each connect to an insulated wire and each has a shield around the wire. These shields are connected to OUT LO, SENSE LO, OUT/SENSE LO, and I/V GUARD, respectively. The I/V GUARD line is connected to I GUARD during operation in the current mode or V GUARD during operation in the voltage mode. This selection is done by relay K11.

When the Calibrator is in standby, all binding posts are open-circuited except the GROUND binding post. In addition, GUARD CHASSIS is connected to S COM by K6. When in the operate condition, this connection is broken (K6 energized) and GUARD CHASSIS is connected to V GUARD via K7, which goes to the GUARD binding post, and to OUT LO via K8. GUARD CHASSIS is also connected to OSC LO GD by K13 except during ac or dc millivolt operation, when instead OSC LO GD is connected to S COM.

Front/Rear Binding Posts 2-20.

An internal cable can be configured to enable either the front panel or panel binding posts. When compared to front panel binding posts, the rear panel provides the same OUTPUT HI, OUTPUT LO, SENSE HI, SENSE LO, AND V GUARD functions. Also, the rear panel provides an I GUARD (current guard) connection for use when the Calibrator is supplying low-level ac current through a long cable. Use of the I GUARD connection removes errors introduced by leakage through such cables. The rear panel binding posts do not provide an AUX CURRENT OUTPUT connection. The procedure to disable the front panel binding posts and enable the rear panel binding posts is to be done at Service Centers, although it is described in this manual in Section 4.

Rear Panel Assembly (A21) 2-21.

The Rear Panel assembly provides physical and electrical connections for the auxiliary amplifiers, along with RS-232-C and IEEE-488 interface connections. Relays on the Rear Panel assembly are used as the interfaces for the 5205A, 5215A, 5220A, or 5725A amplifiers, or for switching the PHASE LOCK IN and VARIABLE PHASE OUT signals.

Three Auxiliary Amplifiers can be physically connected to the Rear Panel assembly of the 5700A/5720A Series II: the 5725A at J7, the 5220A at J4, and either 5205A or 5215A at J3. Only one amplifier can be in use at one time.

- The Rear Panel assembly provides relay switching for 5725A signals. Voltage outputs from the 5725A are routed to the binding posts on the Calibrator. Current outputs are soured at the 5725A OUTPUT binding posts. An alternate configuration is also available, allowing for routing of Calibrator current outputs to the 5725A OUTPUT binding posts.
- When the 5220A (current output) is selected via the front panel, the output of the Calibrator is routed to connector J4 on the rear panel, which is the interface to the 5220A.
- When the 5205A (ac and dc volts) or 5215A (ac volts only) function is selected via the calibrator keyboard, the output of the calibrator is routed to connector J3 (pins 1, 9, 2, and 10) on the Rear Panel assembly.

Filter PA Supply Assembly (A18) 2-22.

The Filter/PA Supply assembly incorporates two sections. The first section contains filters and regulators for some of the in-guard low-voltage supplies, and the second contains the power supply for the Power Amplifier output. Theory for each section is discussed separately.

Digital Section Detailed Circuit Description 2-23.

Detailed descriptions of each assembly in the digital section are provided here. Simplified schematics and block diagrams are provided to supplement the text.

Digital Power Supply Assembly (A19) 2-24.

The Digital Power Supply assembly receives ac voltages from the transformer and provides five regulated dc voltages for use by the CPU, Front Panel assembly, Rear Panel assembly, and the cooling fans. All power supply voltages are referenced to COMMON, which is the transformer center tap for the ±12V supplies. Test points at the top of the assembly can be used to check unregulated input voltages, and regulated dc output voltages. Table 2-2 lists the supplies generated by the Digital Power Supply.

Table 2-2. Supplies Generated by the Digital Power Supply

Signal Name	Test Point	Nominal Output	Tolerance	Current Limit	Rated Output
+75V OUT	TP2	73V	+/-8%	121 mA	100 mA
+35V OUT	TP5	35V	+/-7%	52 mA	40 mA
+12 VOLTS	TP8	12V	+/-5%	1.5A	700 mA
-12 VOLTS	TP10	12V	+/-5%	1.5A	450 mA
+5V	TP12	5.2V	+/-5%	2.4A	2.0A
COMMON	TP13				

+5V Power Supply *2-25.*

The unregulated +5V supply uses CR25-CR28 in a full-wave rectifier configuration with filter capacitors C12, C13, and C14. Capacitors C20 and C21 filter out high-frequency noise. Inductor L8 is a common-mode choke and C11 is a bypass capacitor. The regulator is fused by 3.15A slow-blow fuse F5.

The regulated +5V is generated by three-terminal low-dropout +5V regulator U3 with heat sink. The regulator's output voltage is increased about 0.2V by CR35, a germanium diode connected between the regulator's ground pin and COMMON. Capacitor C14 is for bypass. Capacitor C23 filters out high-frequency noise. Diode CR29 protects the regulator against input shorts, and diode CR30 protects the regulator from reverse voltage. Inductor L7 and C16 further filter the output to P41.

±12V Power Supplies *2-26.*

A full-wave rectifier made of diodes CR17-CR20 and filter capacitors C6 and C7 generate the unregulated +12V and -12V supplies. AC inputs are fused by F3 and F4, both 2A slow blow.

The regulated +12V supply is generated by a three-terminal +12V regulator U1 with heat sink. Capacitors C5 and C9 are for bypass. Diode CR21 protects the regulator from input shorts, and diode CR23 protects the regulator from reverse voltage. Capacitor C22 filters out high frequency noise.

Three-terminal -12V regulator U2 with heat sink generates the regulated -12V supply. Capacitors C8, C10, and C19 are for bypass. Diode CR22 protects the regulator from input shorts, and diode CR24 protects the regulator from reverse voltage.

Inductors L3-L6 filter the regulated outputs. R7 further isolates the ±12V FAN lines from the ±12V power lines. The +12V FAN and -12V FAN lines power the two 24V dc fans inside the calibrator.

+35V Power Supply *2-27.*

The +35V power supply powers the grid drivers and anode drivers on the front panel output display circuitry.

A full-wave rectifier made of diodes CR9-CR12 and filter capacitor C3 generate the unregulated +35V supply. Its input is fused by F2, a 0.125A slow-blow. Capacitor C18 is for bypass. Capacitor C25 filters out high frequency noise.

Zener diodes VR14, VR15 and transistor Q5 generate the +35V regulated output. Zener diodes VR14 and VR15 (both 18V) make up the control element which sets the output voltage. Transistor Q5 is used as an emitter follower. CR13 is the constant current source supplying current to the zener diodes and the base of Q5. Components R5 and Q6 make up the current-limiting circuit. During an over-current condition, the voltage drop across R5 turns Q6 on, thus drawing current away from the base of Q5 and limiting current flow to the output. Diode CR16 protects this circuit from reverse voltage and C4 is a bypass capacitor. Inductor L2 filters the regulated output. Resistor R13 is a bleed-off resistor for C3.

+75V Power Supply 2-28.

The +75V power supply powers the grid drivers and anode drivers on the front panel control display circuitry.

A full-wave rectifier made of diodes CR1-CR4 and filter capacitor C1 generate the unregulated +75V supply. Its input is fused by F1, a 0.315A slow-blow. Capacitor C17 is for bypass. Capacitor C24 filters out high frequency noise.

The +75V regulated output is generated by 36V zener diode VR6, 39V zener diode VR7, and transistors Q1 and Q3. Zener diodes VR6 and VR7 set the output voltage. Transistors Q1 and Q3, in a Darlington configuration for current gain, are used as an emitter follower. Transistor Q4, zener diode VR5, and resistors R2 and R3 make up the constant current source supplying current to the zener diodes and the base of Q3. Current limiting is performed by R1 and Q2 in the same manner as in the +35V supply. Diode CR8 protects the circuit from reverse voltage and C2 is a bypass capacitor. Inductor L1 filters the regulated output. Resistor R6 is a bleed-off resistor for C1.

+35V and +75V Shut-Down Circuit 2-29.

The +35V and +75V high voltage supplies are shut down when a fault occurs in the control display refresh circuitry. This shut-down circuit prevents the Control Display and Output Display from burning out, and also verifies that the master clock is generating control signals for both displays.

During normal operation, 75VSD is low, turning Q10 off. Line RESETL pulls the base of Q9 high through R9, turning Q9 on. This action in turn pulls the junctions of CR31-CR32 and CR33-CR34 low, turning Q7 and Q8 off. The +75V and +35V constant-current sources can then supply the appropriate zener diodes and drive the bases of the respective emitter followers.

When a display refresh fault occurs, the 75VSD line on P41 pin 5C, coming from the Front Panel assembly, goes high. this signal, pulled up by R4, drives the base of Q10 through base resistor R11. Transistor Q10 then saturates, pulling the base of Q9 near ground, turning Q9 off. On power-up or during a CPU reset, the RESETL signal is low, pulling the base of Q9 near ground through R9, also turning Q9 off. Resistor R12 is a turn-off resistor for Q9. Diodes CR31 and CR33 are in a wired-OR configuration. When Q9 is saturated (on), CR31 and CR33 pull their respective junctions to CR32 and CR34 near ground, turning Q7 and Q8 off. When Q9 is off, the junctions are pulled high through R8 and R10, saturating Q7 and Q8 (on). When on, Q7 removes the base drive from Q3, shutting down the +75V supply. Similarly, Q8 removes the base drive from Q5, shutting down the +35V supply.

Diodes CR32 and CR34 simply ensure that Q7 and Q8 are off when Q9 is on. Resistor R8 guarantees that Q7 will hold the +75V supply off until it drops below 15.6V, and R10 holds the +35V supply off to 7.8V.

CPU (Central Processing Unit) Assembly (A20) 2-30.

The CPU (Central Processing Unit) for the Calibrator is a single-board computer based on a 68HC000 microprocessor. The CPU assembly communicates with the Guarded Digital section, the Front Panel assembly, and the Rear Panel assembly. The board can be divided into three primary areas:

- The microprocessor and its support circuitry
- Memory
- Peripheral chips and I/O interfaces

Microprocessor support circuitry consists of a power-up and reset circuit, clock generation, a watchdog timer, address decoders and DTACK (data acknowledge) generator, bus error timeout, and interrupt controller.

Figure 2-5 is a block diagram of the CPU assembly. Table 2-3 is a glossary of the acronyms used in the text and schematic for the CPU assembly.

Power-Up and Reset Circuit 2-31.

The power-up and reset circuitry consists of line monitor chip U1, C5, C6, CR1, R3, Z3, switch SW1, and inverters on U2. This circuit provides a 195 ms reset pulse at power-up or upon pressing and releasing SW1, placing the CPU assembly in a known safe condition. If the power supply glitches or falls below 4.55V ±0.05V, U1 resets the Calibrator. The reset pulse duration is determined by C5. Note that SW1 performs a different function than the front panel RESET button. SW1 is a hardware reset that is hard-wired to and directly read by the microprocessor. The front panel RESET button is a software reset; it tells the system software to restore the Calibrator configuration to a default condition.

The heart of this circuit is the line monitor chip U1. On power-up or when SW1 is pushed, U1 forces an active-low reset pulse on RESETL and an active-high pulse on RESET. RESETL helps to prevent accidental writes to EEPROM and drives an inverter in U2 to turn off LED CR1. CR1 indicates that the +5V supply is on and that the CPU is operating, i.e. not reset. RESETL also resets the rear panel assembly. The other output, RESET, drives two inverters in U2. One of these inverters provides HALT*. The other generates IORESET*, which drives the processor's RESET, and provides a reset for the front panel interface and DUARTs (dual universal asynchronous receiver/transmitter) circuitry.

Clock Generation 2-32.

The clock generation circuit uses components Y1, Y2, U3, U4, R4, R5, C8, C9, and E5. The crystal Y1, along with the resistors, capacitors, and an inverter in U3 generates the 7.3728 MHz primary system clock CLK. This system clock is used by the processor and is divided down by a binary counter (U4) for clocks of 3.6864 MHz, 28.8 kHz, and 450 Hz. The 450 Hz clock is used by the watchdog timer, the 28.8 kHz is used by U6 in the decoding circuit, and the 3.6864 MHz is used by the DUARTs, and the clock filter circuit. Jumper E5 allows for selection of the alternate oscillator (Y2) as the system clock.

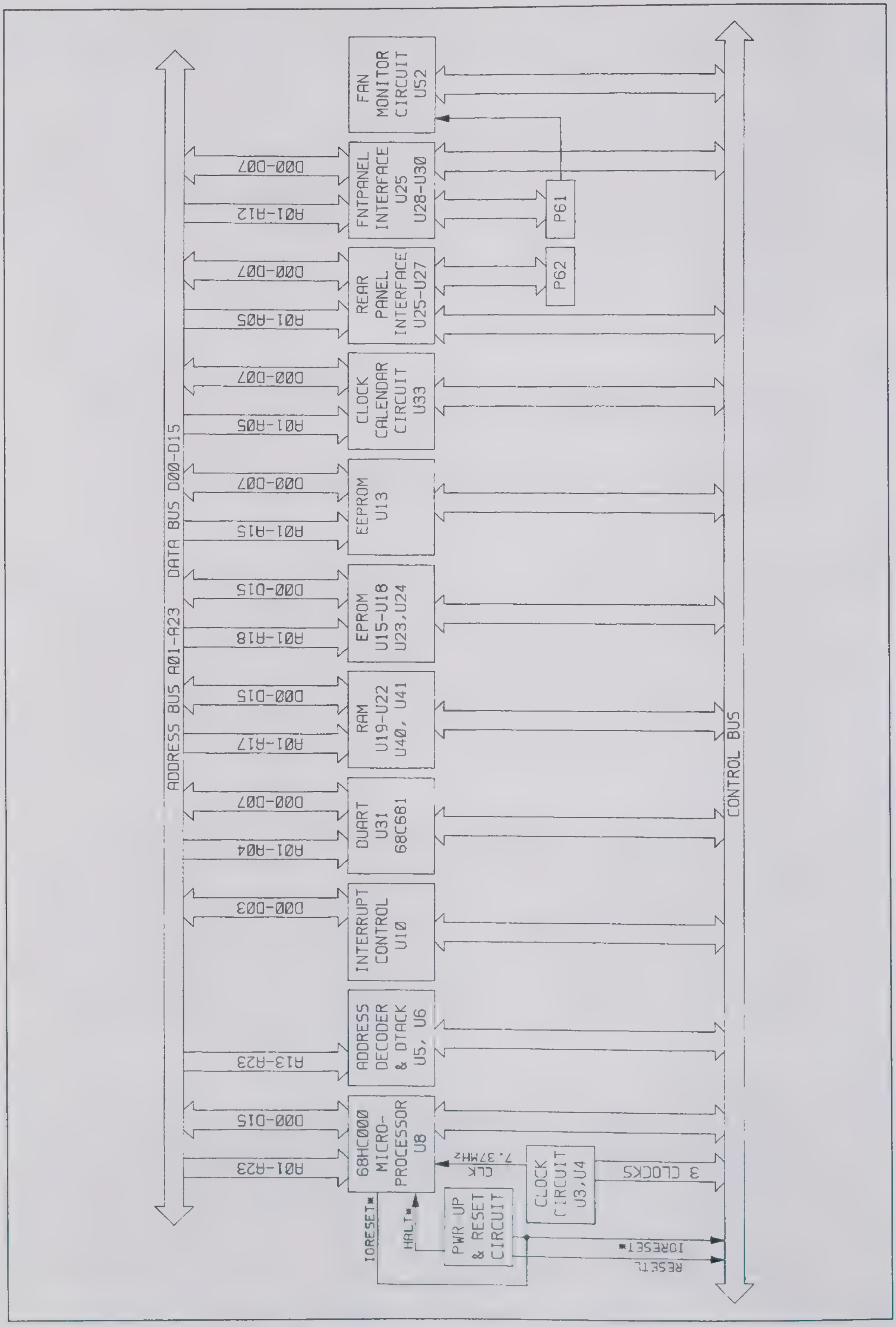


Figure 2-5. CPU Assembly Block Diagram

Table 2-3. CPU Acronym Glossary

Signal Name	Function
A01-A23	Address lines
ADCLKCS*	Clock/calendar (U33) chip select
AS*	Address strobe
BERR*	Bus error
BGACK*	Bus grant acknowledge
BR*	Bus request
BRPDRTINT*	Rear panel DUART interrupt
BRPDTK*	Rear panel data transfer acknowledge
BRPIEEEINT*	Rear panel IEEE-488 interrupt
CLKCALINT*	Clock/calendar interrupt
D00-D15	Data lines
DOGCLR	Dog clear (clears watchdog timer)
DOGINTH	Dog interrupt (interrupt from watchdog timer)
DRTDTK*	DUART data transfer acknowledge
DTACK*	Data transfer acknowledge
E	Enable for 6800 family devices (737.28 kHz clock)
EXDUARTINT*	External DUART Interru
FAN1	Signal monitoring fan 1
FAN2	Signal monitoring fan 2
FANINT*	Fan monitor interrupt
FC0	Function code output 0
FC1	Function code output 1
FC2	Function code output 2
FPDTK*	Front panel data transfer acknowledge
FRNTPNLCS*	Front panel chip select
FRNTPNLEN*	Front panel enable
GCDRTCS*	Guard crossing DUART chip select
GCDUARTINT*	Guard crossing DUART interrupt
INTRCNTL1	Interrupt control 1
INTRCNTL2	Interrupt control 2
IPL0*	Interrupt priority level 0
IPL1*	Interrupt priority level 1
IPL2*	Interrupt priority level 2
KEYBRDINT*	Keyboard interrupt
LDS*	Lower data strobe
MISCCS*	Miscellaneous chip select enable (upper address bits decoder)
NVMCS*	Nonvolatile memory chip select
NVMOE*	Nonvolatile memory output enable
PROM0CS*	PROM 0 chip select (U15 and U16)
PROM1CS*	PROM 1 chip select (U17 and U18)
PROM2CS*	PROM 2 chip select (U23 and U24)
PSFAILINT*	Power supply fail interrupt
RAM0CS*	RAM chip select (U19 and U20)
RAM1CS*	RAM chip select (U21 and U22)
RAM2CS*	RAM chip select (U40 and U41)
R/WR*	Read/write
RDINT*	Read interrupt
RDL*	Read data lower
RDU*	Read data upper
RDY/BSYL	Ready/busy
RPSEL*	Rear panel chip select
RRPNLEN*	Rear panel enable
RXDA	Receive Data Port A
RCVB	Receive Data Port B
SCLK	Serial clock
TXDA	Transmit Data Port A
TXDB	Transmit Data Port B
UDS*	Upper data strobe
WRL*	Write lower
WRU*	Write upper
XDUARTCS*	External DUART chip select

Watchdog Timer *2-33.*

The watchdog timer circuitry uses a 74HC4020 binary counter (U11) to divide the 450 Hz from the clock generation circuit to produce interrupt DOGINTH, signifying that the system may be locked up. This interrupt is generated 1.14 seconds after the last DOGCLR2 signal from interrupt controller U10. Therefore, DOGCLR2 must occur more often then every 1.14 seconds to clear U11 and prevent the watchdog interrupt. Generation of DOGCLR2 is under software control. The watchdog timer can be disabled by cutting jumper E1.

Address Decoding and DTACK (Data Acknowledge) *2-34.*

Two Programmable Logic Devices (PLDs) accomplish address decoding and DTACK (data acknowledge) generation. ICs U5 and U6 provide chip selects and generate acknowledgment signals for those devices without DTACK lines. IC U5 receives DTACK signals from the asynchronous devices and ORs these signals together to form DTACK*. Table 2-4 is the memory map for the system. It shows the chip select, address range, and notes whether AS* (address strobe) or LDS* (lower data strobe) is required.

Table 2-4. CPU Memory Map

Chip Select	Read/Write	Address Range	AS* or LDS* Required?
PROM0CS*	R	0 to 3FFFF	no
PROM1CS*	R	40000 to 7FFFF	no
PROM2CS*	R	80000 to BFFFF	no
RAM0CS*		600000 to 60FFFF	no
RAM1CS*		610000 to 61FFFF	no
RAM2CS*		620000 to 623FFF	no
NVMCS*	R/W	C00000 to CFFFFF	no
MISCCS*	R/W	D00000 to DFFFFF	no
RPSEL*	R/W	D00000 to D01FFF	LDS*
RPDUARTCS*	R/W	D00000 to D0001F	LDS*
RPIEEECS*	R/W	D00020 to D0002F	LDS*
Y52XXRD*	R	D00030 to D00031	LDS*
Y5205WR*	W	D00032 to D00033	LDS*
Y5220WR*	W	D00034 to D00035	LDS*
FRNTPNLCS*	R/W	D02000 to D03FFF	AS*
OTDCS*	R/W	D02000 to D027FF	AS*
DMDCS*	R/W	D02800 to D02FFF	AS*
ENCODERCSR	R	D03000 to D033FF	AS*
ENCODERRESETW	W	D03000 to D033FF	AS*
LED_OUTPUT_ R	R	D03400 to D037FF	AS
LED_LATCH_EN	R/W	D03400 to D037FF	AS*
KEYBOARDCS	R/W	D03800 to D038FF	AS*
GCDRTCS*		D04000 to D05FFF	LDS*
XDUARTCS*	R/W	D06000 to D07FFF	LDS*
RDINT*	W	D08000 to D09FFF	AS*
DOGCLR		D08000 to D09FFF	even only, AS*
ADCLKCS*		E00000 to EFFFFF	AS*

Interrupt Controller 2-35.

PLD U10 is the priority interrupt controller. The interrupt controller reads incoming interrupts and interrupt control lines, then encodes the highest priority interrupt into the interrupt level for the 68HC000. When the 68HC000 responds to an interrupt request, it asks the interrupt controller for an 8-bit vector that corresponds to the pending interrupt of highest priority. The interrupt controller responds with the 4 LSB's of the vector according to how it is programmed. The 4 MSB's are pulled up on resistor network Z1. Table 2-5 shows the interrupts, their priority levels, and vectors.

Table 2-5. CPU Interrupts, Priorities, and Vectors

Interrupt	Priority Level	Vector (Hex)
NMI	7	- (not used)
DOGINTH	6	F4
BRPDRTINT*	5	F6
GCDUARTINT*	5	F7
EXDUARTINT*	5	F8
CLKCALINT*	4	F5
BRPIEEEINT*	4	F9
KEYBRDINT*	3	FA
BPSFAILINT*	2	FB
FANINT*	0	FF (not used)
RDY/BSYL	0	FF (not used)
No interrupt	0	FF

Glue Logic 2-36.

ICs U2, U3, and U9 form the glue logic circuit, which keeps various CPU functions running properly. The four OR gates in U9 and an inverter in U3 use control signals UDS*, LDS*, and R/WR* from the microprocessor to generate control signals WRU*, WRL*, RDL*, and RDU*.

RAM (Random-Access Memory) 2-37.

Random-access memory is contained in three pairs of sockets, U19 and U20, U21 and U22, and U40 and U41. These sockets accommodate either 32K x 8 or 128K x 8 static CMOS RAM modules (32KB or 128 KB each). The Calibrator is shipped with U19-U22 installed, using 32K x 8 parts and providing 128 KB of static RAM.

ROM (Read-Only Memory) 2-38.

Read-only memory is contained in three pairs of sockets, U15-U16, U17-U18, and U23-U24. These sockets accommodate 27010 EPROMS, 128K x 8 devices (128 KB each). Jumpers allow 256 KB devices to be used in their place. The Calibrator is shipped with U15-U18 installed, providing 512 KB of EPROM.

Electrically-Erasable Programmable Read-Only Memory (EEPROM) 2-39.

IC U13 is an EEPROM. The socket accommodates a 32K x 8 device (32 KB of storage.) A jumper is provided to allow an 8K x 8 (8 KB) device to be used in place of the 32 KB device. The Calibrator is shipped with a 32KB EEPROM installed.

The EEPROM requires protection against inadvertent writes during power-up and power-down sequences, which could corrupt calibration constants stored there by the 68HC000. The 32 KB EEPROM provides for software-controlled protection against accidental writes.

Hardware is also used to further ensure data integrity. The EEPROMs are designed so that writes to the device are prevented by holding the output enable line (NVMOE*) low. Diodes CR5, CR6 and CR8, together with resistor R6, perform a wired-OR function for three signals that control NVMOE*. Components R6, CR6 and C17 hold NVMOE* to a valid logic low for typically 37.3 ms during power-up; 26.8 ms minimum, 49.6 ms maximum. Diode CR7 provides a discharge path for C17 on power-down, allowing the operator to quickly turn the Calibrator off then on again, without interfering with the power-up charge time of the capacitor. Diode CR8 allows the normal microprocessor read of the device to take place. And diode CR5 allows power monitoring IC U1 to hold NVMOE* low when the +5V power supply drops below 4.5V on power-down or during power glitches.

DUART (Dual Universal Asynchronous Receiver/transmitter) Circuit 2-40.

The 68C681 DUART (U31) has several functions. Its primary function is to provide the asynchronous serial lines that communicate with the Guarded Digital Controller over the fiber-optic path off the Digital Motherboard. A 75451 driver chip (U32) drives the fiber-optic transmitter on the digital Motherboard.

The DUART has 8 output lines that perform various functions. INTRCNTL1 and INTRCNTL2 go to the interrupt controller and are fed back to the DUART inputs. These are used by the interrupt controller to enable certain interrupts. Line SCLK is a test output of the channel A serial clock.

The DUART monitors the EEPROM ready signal and the FANINT* signal. It also has a spare serial channel that goes to connector J5. Components U44 and U43 convert the TTL-level signals at the DUART to RS-232-C-level signals at J5.

The DUART generates its own DTACK signal, DRTDTK*, which is used by U5 to generate system DTACK, DTACK*. A second DUART, U42, with associated RS-232-C drivers and receivers is used only for test purposes. It generates its own DTACK, wire-ORed to DRTDTK*.

Clock/Calendar Circuit 2-41.

Time and date information is stored in a battery-backed clock/calendar circuit consisting of 32.768 kHz crystal Y3, 3V lithium battery BT1, clock/calendar IC U33, and capacitors C10 and C11. The clock/calendar IC has the necessary circuitry internally to switch operation from the power supply to battery BT1. Pull-up resistors in Z5 off U33 are to ensure low power operation when the +5V supply is off. U33 generates CLKCALINT* under software control.

Clock Filter Circuit 2-42.

The clock filter circuit generates a 3.6864 MHz 200 mV sine wave for the Rear Panel and Front Panel assemblies. This circuit buffers the 3.6864 MHz Clock with an inverter in U3. The circuit contains dc-blocking capacitor C80, two stages of a low pass LC filter (L80 and C81, L81 and C82), transformer T51, and termination resistor R82.

CPU to Rear Panel Interface 2-43.

Components U25, U26, U27, and connector P62 interface the CPU to the rear panel. Bi-directional bus transceiver U26 buffers the data lines. Signal R/WR* controls the transmission direction of the data lines, and RRPNLEN* is the chip enable. IC U25 buffers control lines BRPDRTINT*, BRPIEEEINT*, and BRPDTK*. U27, enabled by RRPNLEN*, buffers address line A01-A05 and control lines WRL* and R/WR*. Control lines RESETL, RPSEL*, TXDB, RCVB, and XMT go directly to connector P62.

CPU to Front Panel Interface 2-44.

Components U25, U28, U29, U30 and connector P61 interface the front panel to the CPU. Bi-directional bus transceiver U30 buffers the data lines. Control signal R/WR* controls the transmission direction of the data lines, and FRNTPNLEN* is the chip enable. IC U28, enabled by FRNTPNLEN*, buffers address lines A05-A12. IC U29, also enabled by FRNTPNLEN*, buffers address lines A01-A04 and control line R/WR*. Two sections of U25 in parallel buffer IORESET*, providing twice the drive current of a single section, generating BRESET*. Three other sections of U25 buffer FPINT*, FPDTK*, and PSFAILINT*. Control line FRNTPNLCS* goes directly to connector P61.

Fan Monitor 2-45.

The fan monitor circuit detects whether one of the two fans is fully or partially shorted, open-circuited, or drawing excessive current. Current-sense resistors on the Digital Motherboard send analog signals FAN1 and FAN2 to the CPU through P61. FAN1 is subtracted from FAN2 in U52D, and the difference is amplified before being sent to a window comparator made up of U52B and U52C (plus associated resistors). Capacitors C12 and C13 act as low-pass filters for the two signals, preventing spurious noise from interfering with detection circuitry.

When the output of U52D is greater than +5V, the output of U52B goes low (to about -11V); otherwise the output is high (about +11V). U52A takes the +5V and generates a -5V reference for comparator U52C. When the output of U52D is more negative than -5V, the output of U52C goes low (to about -11V); otherwise the output is high (about +11V). The outputs of U52B and U52C are wire-ORed through CR2 and CR3, using R52 and R53 to limit current sunk by the comparators when their respective outputs are low. Schottky barrier diode CR4 converts the -11V outputs of the comparators, when either is low, to a TTL-level logic low, which is the active (true) level of FANINT*.

When both fans are functioning properly, diodes CR2 and CR3 are reverse-biased, effectively taking the comparators out of the circuit. At this point, R51 pulls FANINT* to a valid TTL-level logic high, the inactive state of FANINT*. R51 and CR4 level-shift the ±11V signal to valid TTL levels.

Signal FANINT* goes to DUART U31 and to the interrupt controller U10 for further processing. System software monitors FANINT* through U31, and can program the DUART to generate a GCDUARTINT* interrupt signal on FANINT* going low.

Front Panel Assembly (A2) 2-46.

The Front Panel assembly, operating in conjunction with the Keyboard assembly (linked by a cable), is the operator interface to the Calibrator. This assembly contains two separate vacuum-fluorescent displays: the Control Display and the Output Display. Each display has its own control, high voltage drive, and filament-switching circuits. This assembly also contains clock regeneration, refresh failure detect, keyboard scanner, rotary knob encoder, LED drive, and decoding and timing circuitry.

Connector J2 connects this assembly with the Keyboard/Encoder. Connector J1 interfaces with the CPU assembly and the Digital Power Supply assembly via the Digital Motherboard.

Clock Regeneration Circuitry 2-47.

To minimize EMI (electro-magnetic interference), the Front Panel assembly accepts a low-level sine-wave (approximately 200 mV p-p) 3.6864 MHz clock from the CPU assembly and converts it to a TTL-acceptable level. This is done by high-speed differential comparator (U7A), operating on incoming signals 3.6864MHZCLK and 3.6864MHZCLK*. The output of U7A is the input to U8 and is also inverted by U11B to create the 3.6864 MHz clock signal CLOCK. Twelve-stage binary counter U8 divides the 3.6864 MHz clock by eight and U11A inverts the signal to create 460.8 kHz. The master clock is further divided by U8, which outputs a 900 Hz signal on pin 1. These clocks provide system timing for the other ICs on the assembly. A -5.2V supply for U7 is provided by VR5, with C64 acting as the supply bypass.

Refresh Failure Detect Circuitry 2-48.

If a clock failure were to occur, the refresh cycles of the vacuum-fluorescent displays would be interrupted. This condition could damage the tubes if not immediately detected. Refresh failure detect circuitry monitors the GRIDDATA output from the last high voltage driver (U23) for the Control Display. This output (REFRESH) is used to clear a watchdog timer (U6) every refresh cycle. If the refresh is interrupted and GRIDDATA does not occur, the watchdog timer times out and latches U12. Flip-flop U12 generates control lines 75VSD and PSFAILINTR*. Control line 75VSD is routed to the Digital Power Supply assembly to shut down the +35V and +75V power supplies, thus preventing damage to the vacuum-fluorescent displays. Interrupt line PSFAILINTR* is used by PLD U3 to properly blank the Control Display and Output Display through DMDBLANK and OTDBLANK, and alerts the CPU that this failure has occurred.

Decoding and Timing Circuitry 2-49.

Main decoding and master timing functions for the front panel are accomplished by an EP900 PLD (Programmable Logic Device), U3. Two state machines control display refresh and filament switching. Filament switching is handled by two non-overlapping 57.6 kHz signals.

Signals GSTRBE and STROBE are master timing and synchronization signals used by the other ICs. Signal DMDBLANK controls the Control Display grid drivers, ABCLK and CDCLK control the Control Display anode drivers, and OTDBLANK controls the Output Display grid and anode drivers. Front panel DTACK and interrupt functions, and generation of the various chip select and reset signals are also provided by U3. Table 2-6 is a memory map for the front panel.

Table 2-6. Front Panel Memory Map

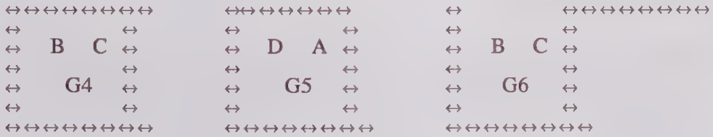
Name	Read/Write	Address
OTDCS*	R/W	D02000 to D027FF
DMDCS*	R/W	D02800 to D02FFF
ENCODERCS*	R	D03000 to D033FF
ENCODERRESET*	W	D03000 to D033FF
LED_OUTPUT_CNTRL	R	D03400 to D037FF
LED_LATCH_EN	W	D03400 to D037FF
KEYBOARDCS*	R/W	D03800 to D03BFF

Control Display Circuitry 2-50.

Control display circuitry consists of a 26-row by 256-column vacuum-fluorescent dot matrix display under the control of PLD U4, four high voltage grid drivers (U20-U23), four high voltage anode drivers (U16-U19), a filament switching circuit, and 1K x 8 (1 KB) dual-port RAM U1.

This display is divided into 129 grids; alternate grids contain two anode columns lettered B C or D A. Grid G129 and column C in grid G128 are not used. Each column contains 26 individual anodes.

IC U4 is an EP900 Programmable Logic Device (PLD). It provides the timing and control signals for control display circuitry. Display data written by the microprocessor into the Control Display's dual port RAM (U1) is read by U4 and sent serially to the high voltage anode drivers. Both the anode and grid drivers are serial TTL-level input, 32-bit parallel high voltage output devices. IC U4 also controls the grid timing and display refresh.



Adjacent columns in adjacent grids are driven, while the opposite columns are turned off. For instance, grid G4 contains columns B and C, and grid G5 contains columns D and A. G4 and G5 are driven simultaneously while anode columns G4-C and G5-D are activated, and G4-B and G5-A are driven off. Next, grids G5 and G6 are driven simultaneously, while columns G5-A and G6-B are activated, and G5-D and G6-C are driven off. This pattern is repeated for all 128 grids at a refresh rate of about 75 Hz.

This particular scheme was selected because of the way the anode drivers are loaded with display data. Both the A and C (U16 and U18), and B and D (U17 and U19) anode drivers' input registers are latched with the same data, while the output drivers are appropriately enabled and displaying the data previously strobed to the driver outputs from the input registers. The input register data is strobed to the output drivers while all of the drivers are disabled, or blanked. Following this, either the A and B drivers are enabled to display the A-B data, when the C and D drivers, latched with A-B data, are disabled, or the C and D drivers are enabled to display the C-D data, when the A and B drivers, latched with C-D data, are disabled.

Control display filament driver circuitry consists of transistors Q1 through Q6 and zener diodes VR1 and VR2, with associated resistors. The transistors are driven by 7406 open collector drivers U13B and U13A. These drivers are controlled by AOUT and BOUT. AOUT and BOUT are synchronous, non-overlapping, three-eighths duty cycle, 57.6 kHz timing signals generated by U3. Each signal is alternately active high for 6.51 us, with a dead time between active signals of about 2.17 us to allow for turn-off times of the drive transistors. When AOUT is high, U13B turns Q2 and Q4 on. Q4 turns Q6 on, providing a path for the filament current through Q2 and Q6. Zener diode VR2 provides the dc voltage offset necessary for proper filament operation. Then when BOUT is high, U13A turns Q1 and Q3 on. Q1 turns Q5 on, providing a path for the filament current through Q3 and Q5, effectively reversing the direction of the voltage driving the filament. Zener diode VR1 provides the dc voltage offset necessary for proper filament operation.

PLD U4 also generates the 225 Hz square-wave SCAN signal used by PLD U9 to control front panel keypad scanning and key debounce.

Dual-port RAM U1 contains all the Control Display data written by the 68HC000 microprocessor on the CPU board. PLD U4 contains a 10-bit address counter which is used by U4 to read the contents of U1. U1 provides a BUSYD signal to U3, which is active low whenever the CPU and U4 try to access the same RAM location at the same time. If the microprocessor attempts to write to the RAM location that U4 is reading (as it refreshes the DMD), U3 uses BUSYD to hold off DTACK to the microprocessor. This prevents the written data from being lost. The other busy signal, generated when U4 attempts to read from a location being written to by the microprocessor, is ignored. Losing display data for one refresh cycle is insignificant.

The Control Display can be blanked to maintain its brightness over years of operation. The Main CPU pulls U10 pin 12 (SQ) low when the Calibrator has been inactive for at least 30 minutes. This action results in U13 E&F being driven low to short the bases of Q5 and Q6 to common, turning off any filament drive to the control display. Since U13 outputs are open-collector, they have no effect on the filament drive circuit when the Main CPU returns U10 pin 12 high.

Output Display Circuitry *2-51.*

Output display circuitry consists of a custom 2-row, 22-character vacuum-fluorescent display under the control of PLD U5. The circuit contains high voltage grid driver U15, high voltage anode driver U14, a filament switching circuit, and a 1K x 8 (1 KB) dual-port RAM, U2.

The custom display is divided into 24 grids. The 22 characters are made up of fourteen seven-segment digits and eight 14-segment characters.

IC U5 is an EP900 PLD, programmed to provide the timing and control signals for the output display circuitry. Display data written by the microprocessor into the Output Display's dual-port RAM U2, is read by U5 and sent serially to the high voltage anode driver. Both the anode and grid drivers are serial TTL-level input, 32-bit parallel high voltage output devices. Only 31 anode driver outputs and 24 grid driver outputs are used, the remaining high voltage outputs are left unconnected. IC U5 also controls grid timing and display refresh.

A special refresh scheme is used by the Output Display to intensify a specific digit to be displayed. This feature is used by the Calibrator when in Error Mode, while editing a value displayed on the Output Display. The digit selected for editing is brighter than the other digits. To accomplish this, U5 monitors data it reads from the dual-port RAM. Following the entry of the fourth data byte to the input registers of the anode driver, the registers are strobed to the high voltage output drivers, then the drivers are enabled. If data bit D7 of the fourth byte is low, the state machine in U5 simply goes on to refresh the next digit at the normal rate of approximately 200 Hz. If, however, bit D7 of the fourth byte is high, the state machine enters a delay routine that adds about 625 us to the normal 5 ms anode and grid on-time, thereby intensifying the digit. Unlike the Control Display, only one grid at a time is turned on.

Output display filament driver circuitry consists of transistors Q7-Q12 and zener diodes VR3 and VR4, plus associated resistors. The transistors are driven by 7406 open-collector drivers U13C and U13D. These drivers are controlled by AOUT and BOUT as in the Control Display. When AOUT is high, U13C turns Q8 and Q10 on. Q10 turns Q12 on, providing a path for the filament current through Q8 and Q12. Zener diode VR4 provides the dc voltage offset necessary for proper filament operation. Then when BOUT is high, U13D turns Q7 and Q9 on. Q7 turns Q11 on, providing a path for the filament current through Q9 and Q11, effectively reversing the direction of the voltage driving the filament. Zener diode VR3 provides the dc voltage offset necessary for proper filament operation.

Dual-port RAM U2 contains all the Output Display data written by the 68HC000 microprocessor on the CPU board. U5 contains a 7-bit address counter which U5 uses to read the contents of U2. U2 provides a BUSYO signal to U3, which is active low whenever the CPU and U5 try to access the same RAM location at the same time. If the microprocessor attempts to write to the same RAM location U5 is reading as it refreshes the Control Display, U3 uses BUSYO to hold off DTACK to the microprocessor. This prevents written data from being lost. The other busy signal, generated when U5 attempts to read from a location being written to by the microprocessor, is ignored. Losing display data for one refresh cycle is insignificant.

IC U5 also generates the FPINTR* (front panel interrupt, active low) signal sent to the 68HC000 microprocessor, telling it there is an encoder or keyboard interrupt. The interrupt inputs to U5, ENCODERINTR (encoder interrupt, active high) and KEYBOARDINTR (keyboard interrupt, active high), are generated by PLDs U24 and U9 respectively.

Keyboard Scanner Circuitry 2-52.

The key matrix is scanned by PLD U9. It sequentially drives one of the eight columns for about 2.2 ms, then reads all six rows of the matrix on each column scan. When a key is pressed and the column associated with that key is scanned, the row associated with that key goes low. If the key is still pressed after a 6.6 ms debounce period, U9 generated signal KEYBOARDINTR. This signal goes to U5 where it generates FPINTR*, which interrupts the 68HC000 microprocessor. The microprocessor generates KEYBOARDCS* through PLD U3, causing U9 to output encoded row and column data on the data bus for the microprocessor to read. This also resets the keyboard interrupt.

The microprocessor controls the speaker, also referred to as the beeper. Writing a logic high on data line D6 to U9 enables the speaker, writing a logic low on D6 disables the speaker. When enabled, a 900 Hz square-wave signal generated by U8 is gated out to the speaker through U9.

Knob Encoder Circuitry 2-53.

Knob encoder circuitry consists of PLD U24 and resistors R22, R23, R26, and R27. The resistors configure the U24 knob inputs as Schmitt trigger inputs, with approximately 400 mV of hysteresis. The Schmitt inputs receive the two quadrature signals from the optical shaft encoders at the knob, and remove digital bounce that can result from slowly rotating the knob. The state machine inside U24 uses these signals to determine direction and amount of rotation.

A feature was incorporated to allow the operator to quickly spin the knob and allow the Calibrator to properly track it in spite of the inherent delay servicing the interrupt. Every time the operator moves the knob through a 180° rotation of a single detent, U24 generates ENCODERINTR which is sent to U5. IC U5 then generates FPINTR*, interrupting the 68HC000 microprocessor. The microprocessor services the encoder interrupt by reading U24. On a read, indicated by a logic low on ENCODERCS*, U24 places the contents of a seven-bit up/down counter on the data bus. The counter keeps track of the number of 180° rotations that have occurred between the time the interrupt was first initiated and the counter is read. The counter is incremented or decremented depending on the direction of rotation. Signal ENCODERRESET*, generated by U3 on a write to the front panel encoder address space, clears the encoder interrupt.

Led Circuitry *2-54.*

The LED circuit controls the four light-emitting diodes mounted on the keyboard assembly. It includes a 74LS373 8-bit latch (U10), and four resistors (R16-R19). The respective LEDs light when the following states are active: external sense (EX SNS), external guard (EX GRD), the wideband module is active (WBND), or when an attached 5725A Amplifier is active (BOOST).

Latch (U10) is controlled by the LED_LATCH_EN signal from the decoding PLD U3. Signal LED_LATCH_EN latches the CPU data bus into the internal latches of U10 on a write to the front panel LED memory space. This data appears at the output when control line LEDENABLE* goes low. Control line LED_OUTPUT_CNTRL from U3 is inverted by U11C to create LEDENABLE*. Table 2-7 shows which line activates each LED.

Table 2-7. Control Lines for the Keyboard LEDs

Keyboard Led	Control Lines
EX SNS	LED1A
EX GRD	LED2A
W BND	LED2B
BOOST	LED1B

Keyboard Assembly (A1) *2-55.*

The Keyboard assembly provides the operator with front panel control of the Calibrator. It connects to the Front Panel assembly (A2) through a cable, and includes an elastomeric keypad, four LEDs, and a rotary encoder (output adjustment) knob.

The elastomeric keypad and the printed circuit board form a 45-switch keyboard arranged in eight columns and six rows. The keyboard scanner circuit on the Front Panel assembly sequentially drives columns one through eight. When a key is pressed, a low appears on the corresponding row as the key's column is scanned. The keyboard scanner circuit encodes the key's row and column location, then takes appropriate action.

The four LEDs (CR1-CR4) are controlled by the LED driver circuit on the Front Panel assembly. LED CR1 is turned on by LED1A when external sensing is selected. LED CR2 is turned on by LED2A when external guard is selected. LED CR3 is turned on by LED2B when the wideband module is active. LED CR4 is turned on by LED1B when an attached 5725A Amplifier is active.

The rotary output adjustment knob activates UUT "Error Mode", allowing the operator to adjust the Calibrator output. It can also control the phase shift for variable phase output. The knob assembly consists of two optocouplers (DT1 and DT2) and a magnetically-detented rotary knob. As the knob is turned, optocoupler DT1 generates a pulse signal on ENCODERA and optocoupler DT2 generates a pulse signal on ENCODERB. These signals are routed to the Front Panel assembly where knob encoder circuitry interprets these signals and takes appropriate action. The current-limiting resistor for LEDs within DT1 and DT2 is located on the Front Panel assembly.

Analog Section Detailed Circuit Description *2-56.*

Detailed descriptions of each assembly in the analog section are provided here. Simplified schematics are provided to supplement the text.

Filter/PA Supply (A18), Low-voltage Filter/Regulator Section *2-57.*

The Filter assembly receives various ac inputs from the main power transformer and provides unregulated dc to the Regulator/Guard Crossing assembly (A17), and regulated dc supplies +5FR1, -18FR1, and -5FR2 to the DAC assembly. The unregulated supplies are listed in Table 2-8 and the regulated supplies are listed in Table 2-9.

Table 2-8. Unregulated Supplies from the Filter Assembly

Signal Name	Nominal Output	Tolerance	Max. P-P Ripple	Rated Output	Test Point
+15 OSCR	27V	+/-8V	2V	200 mA	TP2
-15 OSCR	27V	+/-8V	2V	200 mA	TP5
OSC COM	RETURN				TP4
+5 LHR	12V	+/-4V	3V	3.5A	TP1
-5 LHR	12V	+/-4V	2V	400 mA	TP6
LH COM	RETURN				TP3
+44 SR	60V	+/-15V	3V	155 mA	TP7
-44 SR	60V	+/-15V	3V	460 mA	TP9
44 S COM*					TP22
+17 SR	27V	+/-8V	3V	1.3A	TP10
-17 SR	27V	+/-8V	3V	1.3A	TP14
17 S COM*	RETURN				TP12
+5 FR1R	12V	+/-4V	2V	400 mA	TP17
-18 FR1R	27V	+/-8V	2V	50 mA	TP20
FR1 COM	RETURN				TP19
+30 FR1R	50V	+/-15V	3V	85 mA	TP15
FR1R COM	RETURN				TP16
+30 FR2R	RETURN	+/-15V	3V	85 mA	TP8
FR2 COM					TP11

* 44 S COM and 17 S COM are tied together on the Regulator/Guard Crossing assembly (A17).

Table 2-9. Regulated Supplies from the Filter/PA Supply

Signal Name	Nominal Output	Tolerance	Current Limit	Rated Output	Test Point
-5 FR2	-5V	+/-0.3V	0.15A	0.03A	TP13
FR2 COM	RETURN				TP11
+5 FR1	+5V	+/-0.3V	2A	0.1A	TP18
-18 FR1	-18V	+/-0.9V	2A	0.05A	TP21
FR1 COM	RETURN				TP19

Unregulated OSC Supplies 2-58.

Line OSC COM is the return path for the +15 OSCR and -15 OSCR supplies. These supplies use a full-wave center-tapped configuration. They consist of bridge rectifier CR3 and two filter capacitors, C4 and C6, for +15 OSCR and -15 OSCR, respectively. Inputs are fused with 1.6A slow-blow fuses F1 and F2.

Unregulated LH Supplies 2-59.

Line 5 LH COM is the return path for the +5 LHR and -5 LHR supplies. These supplies use a full-wave center-tapped configuration, and consist of four diodes (CR1, CR2, CR4, CR5) configured as a bridge rectifier.

Capacitors C2 and C3 filter +5 LHR, and C5 filters -5 LHR. Capacitor C1 reduces the level of generated transients.

Unregulated S Supplies 2-60.

The ±44 SR supplies use full-wave center-tapped rectifiers. Bridge rectifier CR6 is followed by two filter capacitors C7 and C8 for the +44 SR and -44 SR supplies, respectively. Inputs are fused by 0.5A slow blow fuses, F3 and F5. The ±17 SR supplies also are full-wave center-tapped, consisting of four diodes (CR8, CR10, CR12, CR13) configured as a bridge rectifier. Capacitors C13 and C14 filter the +17 SR supply, while C15 and C16 filter the -17 SR supply.

Triac Circuit 2-61.

The triac circuit protects the Calibrator if it is inadvertently plugged into an excessively high line voltage. For example, it protects the Calibrator if it is plugged into a 230V line when the rear panel line voltage select switches are set for 115V operation.

This circuit contains triac CR19, zener diodes VR20, VR21, resistor R1, and capacitor C23. The zener diodes set a trip voltage of 82V. If the ac voltage across the main transformer secondary for the ±17V supply exceeds 82V, the triac fires, shorting out the winding, which causes the main transformer primary fuse to blow.

FR1 Supplies 2-62.

Line FR1 COM is the return path for the unregulated +5 FR1R raw supply and the regulated +5 FR1, and -18 FR1 supplies. Each supply uses a full-wave bridge configuration.

The unregulated +5 FR1R supply consists of bridge rectifier CR15 and filter capacitor C19. The input is fused with 1.6A slow-blow fuse F8. The regulated +5 FR1 supply uses the unregulated +5 FR1R supply and contains regulator U2, filter capacitor C20, and protection diode CR16.

The -18 FR1 supply consists of bridge rectifier CR17 and filter capacitor C21. Its input is fused with 0.5A slow-blow fuse F9. The regulated -18 FR1 supply uses the unregulated -18 FR1 supply and contains regulator U3, filter capacitor C22, and protection diode CR18.

Unregulated FR1 Supply 2-63.

FR1R COM is the return path for the unregulated +30 FR1 supply. This supply uses full-wave bridge rectifier CR14 and filter capacitor C18. Its input is fused with 0.5A slow-blow fuse F7.

FR2 Supplies *2-64.*

FR2 COM is the return path for unregulated +30 FR2R supply and regulated -5 FR2 supply. Each supply uses a full-wave, bridge configuration. The unregulated +30 FR2R supply consists of bridge rectifier CR7 and filter capacitor C9. Its input is fused with 0.5A slow-blow fuse F4. The -5 FR2 supply consists of bridge rectifier CR11, filter capacitor C11, regulator U1, bypass capacitor C12, and protection diode CR9. The input is fused with 315 mA slow-blow fuse F6.

Filter/PA Supply (A18), Power Amplifier Output Supply Section *2-65.*

The power amplifier output power supply section of the Filter/PA Supply assembly (A18) receives ac voltage from the main power transformer to generate power supplies +PA and -PA for the output stage of the Power Amplifier assembly (A16). These two power supplies can be switched between the following three modes of operation, depending on the needs of the Power Amplifier.

- +PA and -PA to ±185V respectively.
- +PA and -PA to ±365V respectively.
- +PA and -PA are both turned off.

Figure 2-6 is a simplified schematic for the Power Amplifier Output Supply section of this assembly.

±PA Supplies Digital Control *2-66.*

Circuitry to control the three modes of operation of the +PA and -PA supplies is located on the Power Amplifier Digital Control SIP assembly (A16A1). This SIP assembly is mounted on the main Power Amplifier assembly (A16). Not on the assembly is the quad comparator U201.

The main Power Amplifier assembly generates four control lines:

- +HI/LO V
- LO/HI I
- +ON/OFF
- H/LV S

Component Z201 pulls these signals up. At calibrator power up, the ±PA supply is off. The Power Amplifier Digital Control SIP (A16A1) selectively pulls these control lines low to achieve the two modes of operation. Pulling control lines +HI/LO V and +ON/OFF low sets the +PA supply to +365V. Releasing +HI/LO V changes the +PA supply to 185V.

The comparator (U201) provides level shifting to control the PMOSFETS in the -PA circuit in a similar way. Signal -ON/OFF is generated from +ON/OFF, and -HI/LO V from -H/LV. Control line +LO/HI I switches transistor Q217 which controls relay K201. Relay K201 selects the current limit for both +PA and -PA supplies.

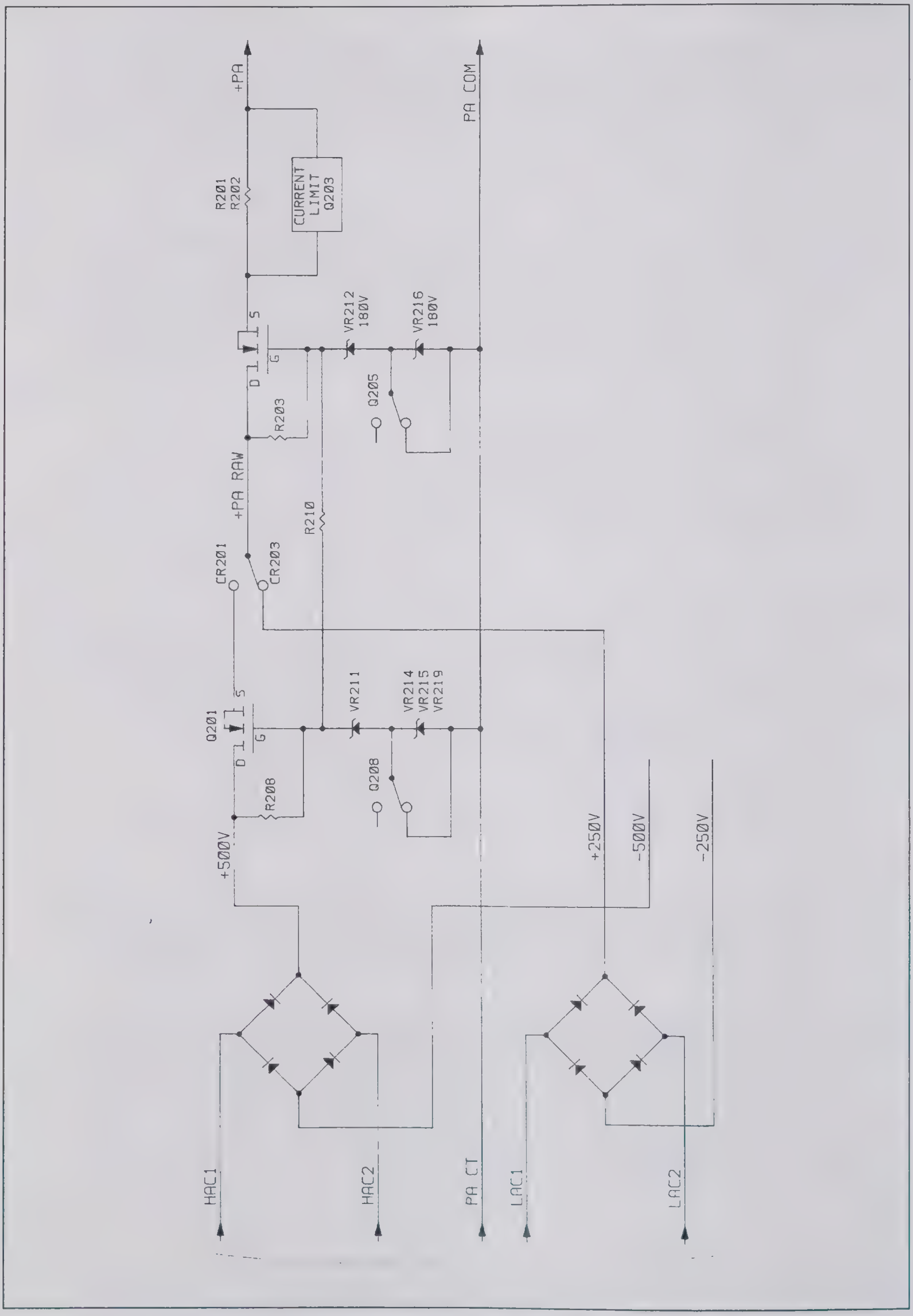


Figure 2-6. Power Amplifier Output Supply Simplified Schematic

±250V and ±500V Supplies *2-67.*

Input signals PA CT, PA HAC1, PA HAC2, PA LAC1, and PA LAC2 come from the main transformer.

- PA CT is the center tap.
- PA HAC1 and PA HAC2 are high voltage taps with approximately 400V rms and are fused by F201 and F204 respectively.
- PA LAC1 and PA LAC2 are lower voltage taps with approximately 200V rms and are fused by F202 and F203 respectively.
- PA LAC1 and PA LAC2 and bridge rectifier CR222 generate the unregulated ±250V supplies.
- PA HAC1 and PA HAC2 and diodes CR217, CR218, CR220, CR221, CR223, CR224, CR227, and CR228 are in a bridge rectifier configuration to generate the unregulated ±500V supplies.

When the PA supply outputs ±185V, current is drawn only from the lower voltage taps LAC1 and LAC2.

+PA and -PA Supplies *2-68.*

Unregulated voltage for +PA is selected between the +250V and +500V unregulated supplies by control line +HI/LO V and diodes CR201, CR203, CR208, and CR210.

Transistor Q204 is a current source that biases VR212 and VR216.

Supply +PA is +185V when the +HI/LO V signal is above 3V. (Transistors Q205 and Q208 are turned on.) Transistor Q205 shorts VR216, while Q208 places a short across VR214, VR215, and VR219. A voltage of +185V appears at the gate of Q202 because of VR212. Approximately 140V appears at the gate of Q201. This 140V and about 250V at the anode of CR208 reverse biases CR201 and CR210, thereby shutting off Q201. Current flows out of the 250V unregulated supply through CR203 and Q202. Regulated supply voltage +PA is determined by the gate voltage of Q202, which is about 190V when +HI/LO V is above 3V.

When +HI/LO V is close to 0V, both Q208 and Q205 are turned off, and over 400V appears at the gate of Q201. CR203 and CR208 are reverse biased, and the supply current flows from the +500V unregulated supply through Q201, CR201, and Q202. The gate voltage of Q202 is approximately 370V, nearly the same as +PA.

The -PA side works exactly like the +PA side except -PA is switched between -185V and -365V by control line -HI/LO V.

The ±PA supplies can be replaced by the ±44SR unregulated supplies by moving switch S201 switched towards the top edge of the board. This feature provides the means to troubleshoot the Power Amplifier using reduced voltages.

Note

Make sure S201 is returned to the ±PA position before resuming normal operation.

±PA Supply Current Limit *2-69.*

The current limit for both the +PA and -PA supplies is set to either about 90 mA (K201 de-energized) or 150 mA (K201 energized) by K201. Control line +LO/HI I controls relay K201. The high-current mode (150 mA) is used during operation in the 1100V dc range and the 2.2A range.

Output current on the +PA side is sensed between the emitter and base of Q203 by R202 and/or R201. Supply +PA shuts off to near 0V when enough current is flowing through +PA to forward-bias Q203. Then, current though Q203 charges capacitor C209 through R214 to a voltage above the threshold voltage at the inverting input of comparator U201C. The overcurrent condition must persist for about 75 ms for C209 to charge above the threshold. The output of U201 goes high, turning on Q207. This forces the zener diode bias current to flow through Q207 instead of VR212 or VR216, leaving only a few volts at the gate of Q202, thus shutting +PA off. The output of U201C also saturates Q218 and reduces the comparator threshold voltage to near 0V. This provides the comparator with hysteresis; C209 has to discharge close to 0V before +PA can turn on again. The +PA supply cycles on and off as long as the overcurrent condition exists.

Transistor Q206 provides another current limit. While otherwise similar to the Q203 limit, the Q206 current limit turns on at 0.5A and turns off immediately without any delay. The Q206 limit thereby protects the supply under short circuit conditions.

Current limiting on the -PA side works similarly to the +PA side with one difference. That is that shutoff of -PA can happen under two circumstances:

- -PA is loaded beyond its current limit.
- +PA is shut off. (Shut off of -PA is slaved to shut off of +PA.)

Regulator/Guard Crossing Assembly (A17) 2-70.

The Regulator/Guard Crossing assembly (A17) provides two separate functions: voltage regulation for the analog power supplies, and digital control of the guard crossing. The voltage regulation portion is described first followed by the digital control portion. Refer to the schematic diagrams for the Regulator/Guard Crossing Assembly for this discussion.

Voltage Regulator Circuitry 2-71.

The regulator circuit receives unregulated dc from the regulator filter circuit on the Filter/PA Supply assembly (A18) and provides 13 regulated dc outputs and 1 unregulated dc output for the various analog assemblies. Table 2-10 lists the regulated supplies from the Regulator/Guard Crossing Assembly.

Regulated OSC Supplies 2-72.

The +15 OSC and -15 OSC supplies are used exclusively by the Oscillator Output (A12) and Oscillator Control (A13) assemblies. OSC COM is the return path for these supplies. The +15 OSC uses the unregulated +15 OSCR from the Filter assembly and consists of three-terminal TO-220 regulator U2 with heat sink, bypass capacitors C1 and C2, and protection diodes CR2 and CR3. The -15 OSC uses the unregulated -15 OSCR from the Filter assembly and consists of three-terminal TO-220 regulator U3 with heat sink, bypass capacitors C4 and C5, and protection diodes CR5 and CR7. Capacitors C2 and C5 improve the stability of U2 and U3 respectively. Diodes CR3 and CR5 protect U2 and U3 from reverse voltages. Diodes CR2 and CR7 protect U2 and U3 from input shorts.

Table 2-10. Regulated Outputs from the Regulator/Guard Crossing Assembly

Signal Name	Nominal Output	Tolerance	Current Limit	Rated Output	Test Point
+15 OSC	+15V	+/-800 mV	2A	200 mA	TP3
-15 OSC	-15V	+/-800 mV	2A	200 mA	TP5
+5RLH	+5.975V	+/-425 mV	2A	600 mA	TP14
+5LH	+5.1V	+/-300 mV	2A	600 mA	TP11
-5LH	-5V	+/-300 mV	2A	400 mA	TP15
+44S	+44.15V	+/-2.03V	0.5A	140 mA	TP13
-44S	-44.15V	+/-2.03V	0.5A	140 mA	TP16
+17S	+17.000V	+/-475 mV	4A	1.0A	TP8
-17S	-17.000V	+/-835 mV	6A	1.0A	TP12
15S	-15V	+/-800 mV	2A	300 mA	TP19
+30FR1	+30.96V	+/-1.7V	1A	85 mA	TP2
+30FR2	+30.96V	+/-1.7V	1A	85 mA	TP7

Regulated LH Supplies 2-73.

LH COM is the return path for the +5RLH, +5LH, -5LH and +8RLH supplies. The +5RLH, +8RLH, and +5LH supplies use the unregulated +5LHR supply from the Filter assembly. The +5RLH supply uses three-terminal TO-3 regulator U11 with heat sink, bypass capacitors C20 and C21, protection diodes CR17 and CR20, and the diode combination of CR34 and CR35. The +5LH supply uses three-terminal TO-3 regulator U8 with heat sink, bypass capacitor C16, protection diodes CR14 and CR16, and resistor R13. The -5LH supply uses the unregulated -5LHR from the Filter assembly and consists of three-terminal TO-220 regulator U12 with heat sink, bypass capacitors C23 and C24, and protection diodes CR21 and CR24. Capacitors C16, C21, and C24 improve the stability of U8, U11, and U12 respectively. Diodes CR14, CR17, and CR24 protect the regulators from input shorts. Diodes CR16, CR20, and CR21 protect the regulators from reverse voltage. Resistor R13 and diodes CR34 and CR35 increase the output of regulators U8 and U11. The unregulated +8RLH supply is generated by fusing the unregulated +5LHR supply from the Filter assembly with 3.15A slow-blow fuse F1.

Regulated S Supplies 2-74.

Line S COM is the return path for the +44S, -44S, +17S, -17S, +15S and -15S supplies. Line S COM is also connected to LH COM. The +44S supply uses the unregulated +44SR from the Filter assembly. This supply uses three-terminal TO-39 regulator U10, Q2, VR3, VR4, VR5, R20, R14, R15, CR18, CR19, CR25, C17, C18, C19, C65, PTC resistor R60. The regulator IC (U10) provides the current and thermal limiting. Its regulated output voltage is set by R14 and R15, yielding a nominal output of +44.15V. Components Q2, R20, VR3 and VR4 act as an emitter follower to protect the regulator against a potentially excessive input-output voltage differential in the event of a short circuit. Capacitor C65 filters this voltage to the regulator. Diodes CR19 and CR25 protect the regulator against shorts at the input, while CR18 protects the regulated output from reverse voltage. Capacitors C17 and C18 are for bypass. Capacitor C19 improves rejection of input variations. Components U10 and Q2 have heat sinks to provide thermal protection for both normal and short-circuit conditions. The regulator is shunted by R60 and VR5, which normally pass 28 mA of current to remove the power from the regulator. In an output short condition, the value of the PTC increases, limiting current through the device to less than 17 mA at 25°C.

The -44S supply uses the unregulated -44SR supply from the Filter assembly. This supply uses three-terminal TO-39 regulator U13, Q1, VR1, VR2, VR6, R17, R18, R19, PTC Resistor R61, CR22, CR23, CR32, CR33, C22, C25, C26, and C66. The regulator IC, U13, provides the current and thermal limiting. Its regulated output voltage is set by R17 and R18, yielding a nominal output of -44.15V. Components Q1, R19, VR1, VR2 and CR32 act as an emitter follower and protect the regulator against a potentially excessive input-output voltage differential if a short circuit occurs. Capacitor C66 filters the voltage to the regulator. The regulator is shunted by R61 and VR6, which pass 28 mA. In an output short condition, the value of the PTC increases, limiting current through the device to less than 17 mA at 25°C.

Diode CR32 removes VR2 from the circuit in a shorted condition to meet U13's input-output differential specifications. Diodes CR22 and CR33 protect the regulator against shorts at the output, while CR23 protects the regulated output from reverse voltage. Capacitors C25 and C26 are for bypass. Capacitor C22 improves rejection of any input variations. The heat sink on regulator U13 guarantees thermal protection for both normal and short-circuit operating conditions.

The +17S supply uses the unregulated +17SR supply from the Filter assembly. This supply uses three-terminal TO-3 regulator U6 with heat sink, and R5 and R6. The output voltage is set by resistors R5 and R6 in the same manner as the +44S supply. Capacitors C8 and C9 are for bypass. Capacitor C11 improves ripple rejection. Diodes CR8 and CR26 protect the regulator against shorts at the input, while CR11 protects the regulated output from reverse voltage.

The -17S supply uses the unregulated -17SR supply from the Filter assembly. It uses three-terminal TO-3 regulator U7 and R10 and R11. The output voltage is set by resistors R10 and R11 in the same manner as the -44S supply. Capacitors C13 and C15 are for bypass. Capacitor C14 improves ripple rejection. Diodes CR15 and CR27 protect the regulator against shorts at the input, while CR13 protects the regulated output from reverse voltage.

The +15S supply uses the unregulated +17SR supply from the Filter assembly. It consists of +15V three-terminal TO-220 regulator U4. Capacitor C27 is required for the stability of U4. Diode CR28 protects the regulator against shorts at the input, while CR29 protects the regulated output from reverse voltage.

The -15S supply uses the unregulated -17SR supply from the Filter assembly. It consists of -15V three-terminal TO-220 regulator U9. Capacitor C29 stabilizes U9. Diode CR31 protects the regulator against shorts at the output, while CR30 protects the regulated output from reverse voltage.

FR1 Supply 2-75.

FR1 COM is the return path for the +30FR1 supply. This supply uses the unregulated +30FR1R supply from the Filter assembly and consists of three-terminal TO-39 regulator U1 with heat sink, bypass capacitors C3 and C6 and protection diodes CR1, CR4, and CR6. Resistors R1 and R2 set the output voltage in the same manner as the +44S supply. Capacitor C7 improves ripple rejection. Diodes CR1 and CR4 protect U1 against input shorts, while CR6 protects against reverse voltage.

FR2 Supply 2-76.

FR2 COM is the return path for the +30FR2 supply. This supply uses the unregulated +30FR2R supply from the filter assembly and consists of three-terminal TO-39 regulator U5 with heat sink, bypass capacitors C10 and C28, and protection diodes CR9, CR10, and CR12. Resistors R4 and R8 set the output voltage in the same manner as the +44S supply. Capacitor C12 improves ripple rejection. Diodes CR9 and CR10 protect U5 against input shorts, while CR12 protects against reverse voltage.

Guarded Digital Control Circuitry *2-77.*

The Inguard CPU controls all the analog assemblies. It communicates with the Unguarded CPU assembly (A20) through a serial fiber-optic link. The Inguard CPU is a Hitachi 637A01Y0 CMOS microcontroller (U56) with 16K x 8 bit (16 KB, or 16 kilobyte) internal CMOS EPROM. Support circuitry includes 8K x 8 bits (8 KB) of external CMOS static RAM, watchdog timer circuitry, reset and power glitch detect circuitry, test switches, a serial fiber-optic link to the unguarded CPU, and decoders and buffers to interface to the guarded digital bus. The assembly also generates an 8 MHz sine wave for use by some of the analog assemblies.

Inguard CPU Memory Map 2-78.

Table 2-11 shows the memory map of the Inguard processor.

Table 2-11. Inguard CPU Memory Map

Address Space (Hex)	Name	Use
0000 - 0027		Internal Registers on the 6301
0028 - 003F		Unused memory space
0040 - 013F		Internal RAM 256 Bytes
0140 - 3FFF	CS0*	Unused memory space
4000 - 4007	CS1*	Wideband Output (A5)
4008 - 400F	CS2*	Current/Hi-Res (A7)
4010 - 4017	CS3*	Switch Matrix (A8)
4018 - 401F	CS4*	Ohms Cal (A9)
4020 - 4027	CS5*	Unused
4028 - 402F	CS6	DAC (A11)
4030 - 4037	CS7*	DAC (A11)
4038 - 403F	CS8*	Current/Hi-Res (A7)
4040 - 4047	CS9*	Oscillator Control (A12)
4048 - 404F	CS10*	Oscillator Output (A13)
4050 - 4057	CS11*	High Voltage Control (A14)
4058 - 405F	CS12*	Power Amplifier (A16)
4060 - 4067	CS13*	Rear Panel (A21) Boost
4068 - 406F	CS14*	Current/Hi-Res (A7)
4070 - 4077	CS15*	Wideband Oscillator (A6) Unused
4078 - 407F		Unused
4080 - 5FFF		Unused(memory overlay of 4000-407F)
6000 - 9FFF		Unused
A000 - BFFF		External RAM
C000 - FFFF		Internal ROM or EPROM

Inguard Memory Configuration 2-79.

The microcontroller (U56) has 16 KB (kilobytes) of internal EPROM program memory. IC U62 provides 8 KB of external static CMOS RAM, with a jumper option for a plug-in replacement with a 2 KB device.

Inguard Clock Circuit 2-80.

This circuit uses 8 MHz crystal Y52 and step-down transformer T51 to generate a low-level (200 mV p-p) 8 MHz clock used by other guarded assemblies throughout the calibrator. Transformer (T51) has a center-tapped secondary, and provides CLK COM, CLK and CLK*. The CLK and CLK* sine-wave signals are sent to certain analog assemblies where they are converted into square wave clock signals for timing purposes.

Inguard Watchdog Timer 2-81.

The watchdog timer circuit uses a 74HC4020 (U59) and part of Programmable Logic Device (PLD) U58. The microcontroller (U56) generates a 19.2 kHz square wave (SCLK) on pin 11. The frequency of this clock is the same as the baud rate of the serial interface. Once the clock frequency is initialized, it runs without software supervision. This clock drives U59, which divides by 16384 to obtain a logic low interval of 427 ms followed by a logic high interval of 427 ms. The output of the U59, POPIN, goes to the PLD, which asserts POP to the analog hardware and NMIPOP* to the processor if U59 is not reset every 427 ms. The PLD also asserts POP on power-up and on any hardware reset. In order to prevent POP and NMIPOP*, the watchdog counter must be reset by reading or writing any analog hardware, or by toggling the POPCLRL line. The POPCLRL line is also used to disable the watchdog by going low.

Power-Up and Reset Circuitry 2-82.

This circuit consists of U60, SW51, C55, C56, R52, and Z51. The line monitor chip (U60) detects three events: the power supply falling below 4.5V, reset being initiated by closure of momentary contact switch SW51, or BREAK being asserted from the break detection circuitry. If any of these conditions occurs, U60 resets the board for 130 ms. Pin 5 of U60 is an open-collector output, pulled high by pin 12 of Z51.

Break Detection 2-83.

The break-detect circuit acts as a serial communications break detector enabling the CPU assembly (A20) to reset U56 and U58 via the power-up and reset circuitry. This break-detect circuit uses a 74HC4020 binary counter (U63) and an inverter U51C. The microcontroller (U56) outputs the 1.2288 MHz ECLK clock on pin 64. This signal clocks U63, which in turn divides the signal by 16,384 to produce successive logic low and high intervals (each of 6.67 ms) at the BREAK output (U63, pin 3). Under normal conditions the RCV (receive) line is high to hold U63 clear. The main 68HC000 CPU can force a reset of the Guard Crossing over the fiber-optic link by holding RCV low for more than 6.67 ms, which causes BREAK to go high. BREAK, inverted by U51C, is used by the reset circuitry to force a Guard Crossing reset via RESET*.

Fiber-Optic Link to CPU 2-84.

Guarded digital and analog circuits are isolated from the unguarded CPU assembly (A20) by a fiber-optic link that asynchronously transmits serial data. On the transmit side, the microcontroller transmit output (XMT) controls a 75451 (U57) which drives fiber-optic transmitter J72 mounted on the Analog Motherboard. Receive signal RCV comes from fiber-optic receiver J71 also mounted on the Analog Motherboard. The receiver converts the light signal to TTL levels that become the RCV signal at the microcontroller. A fiber-optic cable links the fiber-optic transmitter on the Analog Motherboard to the fiber-optic receiver on the Digital Motherboard. Another fiber-optic cable links the other receiver/transmitter pair on the motherboards.

Interface to Guarded Digital Bus 2-85.

The interface to the guarded digital bus consists of a 74HCT245 (U55), a 74HCT244 (U52), two 74HC137s (U53 and U54), inverters U51B and U51D, resistor packs Z52, Z53, and Z54, and the POP line from U58. U52A and U52B buffer various control and address lines. Resistors from Z52 pull the lines of U52A to desired inactive states when BUSEN* is at a logic high, disabling the bus. U55 is a bi-directional data bus buffer (D0-D7). Resistor packs Z53 and Z54 match the lines of the buffered data bus, reducing reflected noise. ICs U53, U54, and U51D perform a 4-to-16 decode of address lines A3-A6, generating 16 chip-select lines (CS0*-CS15*) on the guarded digital bus. These 16 signals select the various assemblies on the Analog Motherboard. U51B buffers and inverts the INT interrupt signal from the DAC assembly. The POP signal from U58 is a reset line sent to the analog assemblies.

Inguard CPU Interrupts 2-86.

The Inguard CPU microprocessor handles many different interrupts. These are listed in Table 2-12 in order of priority with the highest priority interrupts first.

Table 2-12. Inguard CPU Interrupts

Vector		Interrupt	Description
MSB	LSB		
FFFE	FFFF	*RES	Power Up Reset
FFEE	FFEF	TRAP	Address error or op code error
FFFC	FFFD	!NMI	Non maskable interrupt (NMIPOPL)
FFFA	FFFB	SWI	UNUSED
FFF8	FFF9	!IRQ1	!IRQ1,ISF (A/DINTL)
FFF6	FFF7	ICI	Timer 1 input capture (unused)
FFF4	FFF5	0CI	Timer 1 output compare 1,2 (unused)
FFF2	FFF3	TOI	Timer 1 overflow (unused)
FFEC	FFED	CMI	Timer 2 counter match
FFEA	FFEB	!IRQ2	UNUSED
FFF0	FFF1	SIO	RDRF + ORFE + TDRE + PER

RDRF = Receive Data Register Full
ORFE = Overrun Framing Error
TDRE = TRANSMIT DATA REGISTER EMPTY
PER = Parity Error

Switch Matrix Assembly (A8) *2-87.*

Refer to Figure 2-7 for a simplified schematic of the Switch Matrix assembly (A8). The Switch Matrix assembly does the following tasks:

- Coordinates the flow of signals from each analog assembly (excepting the Wideband AC Module (Option -03)) to the calibrator's binding posts. This communication determines the calibrator's range.
- Coordinates the connection of various analog and digital common lines during operate, standby, and calibration modes.
- Controls such binding post functions as operate/standby, internal/external sense, and internal/external guard.
- Provides an internal cal zero amplifier used in the calibration of offsets for all dcv ranges (except the 1100V range).

The Switch Matrix assembly consists of 33 latching type, two- and four-pole relays. The relays are driven by special driver chips, which are controlled by the assembly's 24-output 82C55 chip. The Switch Matrix also contains the 5700A-4HR1 Temperature-Controlled Precision DC Amplifier Hybrid and RNET assembly, which is used when the calibrator is in the dc 2.2V or 220 mV range. The resistor network also is used to create resistive dividers to generate the ac or dc 220 mV, ac 22 mV, and ac 2 mV ranges. Additional analog circuitry in the Switch Matrix Assembly includes the dc 2.2V range output stage, the internal cal zero amplifier, FETs to support assembly calibration, assembly diagnostics, and circuitry to control some of the motherboard relays.

Switch Matrix Digital Control *2-88.*

Refer to sheet four of the Switch Matrix schematic diagram for the following discussion. The heart of the Switch Matrix digital control circuitry is an 82C55 Programmable Peripheral Interface IC (U1) under software control via the guarded digital bus. This IC has three ports that generate 24 outputs. These outputs are used to control eight UCN5801 Latching Driver ICs (U5-U12) controlling all Switch Matrix latching relays, one UCN5801 Latching Driver (U13) controlling the 10 non-latching relays on the motherboard, a 4028 decoder (U2), five FET switches (Q6-Q7, Q9-Q11), and an analog multiplexer (U4) for self diagnostics.

Eight UCN5801 latching driver ICs (U5-U12) drive Switch Matrix latching relays. Port A (PA0-PA7) from U1 provides a common input bus. Each driver chip has a separate strobe line. A 4028 decoder (U2) generates strobe lines U5STB-U13STB for strobing U5-U13 respectively. These individual strobe lines are decoded from PB0-PB3 of U1. When a strobe line is selected, the data on the bus is strobed in the respective driver chip. The output enables are controlled directly by PC0-PC3 of U1. One bit of port C enables two drivers. PC0 enables U5 and U6, PC1 enables U7 and U8, PC2 enables U9 and U10, and PC3 enables U11 and U12. By enabling only two driver ICs at a time, excessive power supply current draw is prevented. To ensure that the relays are latched properly, the driver chips must be enabled for 10 ms. As an example, the following steps are taken to set up relays in the first bank:

1. Write the proper data for the relays associated with driver U5 (K2,K9, K11, and K15) to port A of the 82C55.
2. Write 0 hex to PB0-PB3 to make U5STB go high. Now write 9 hex toPB0-PB3 to make all strobe lines go low. The data has now been strobed into U5.
3. Write the proper data for the relays associated with U6 (K3, K4, K5, and K24) to port A of the 82C55.
4. Write 1 hex to PB0-PB3 to make U6STB go high. Now write 9 hex toPB0-PB3 to make all strobe lines go low. The data has now been strobed into U6.
5. Write FE hex to port C (PC0 is low), wait 10 ms and write FF hex to port C. This takes the outputs of U5 and U6 out of tri-state and allows the proper relay coils to be energized for 10 ms.

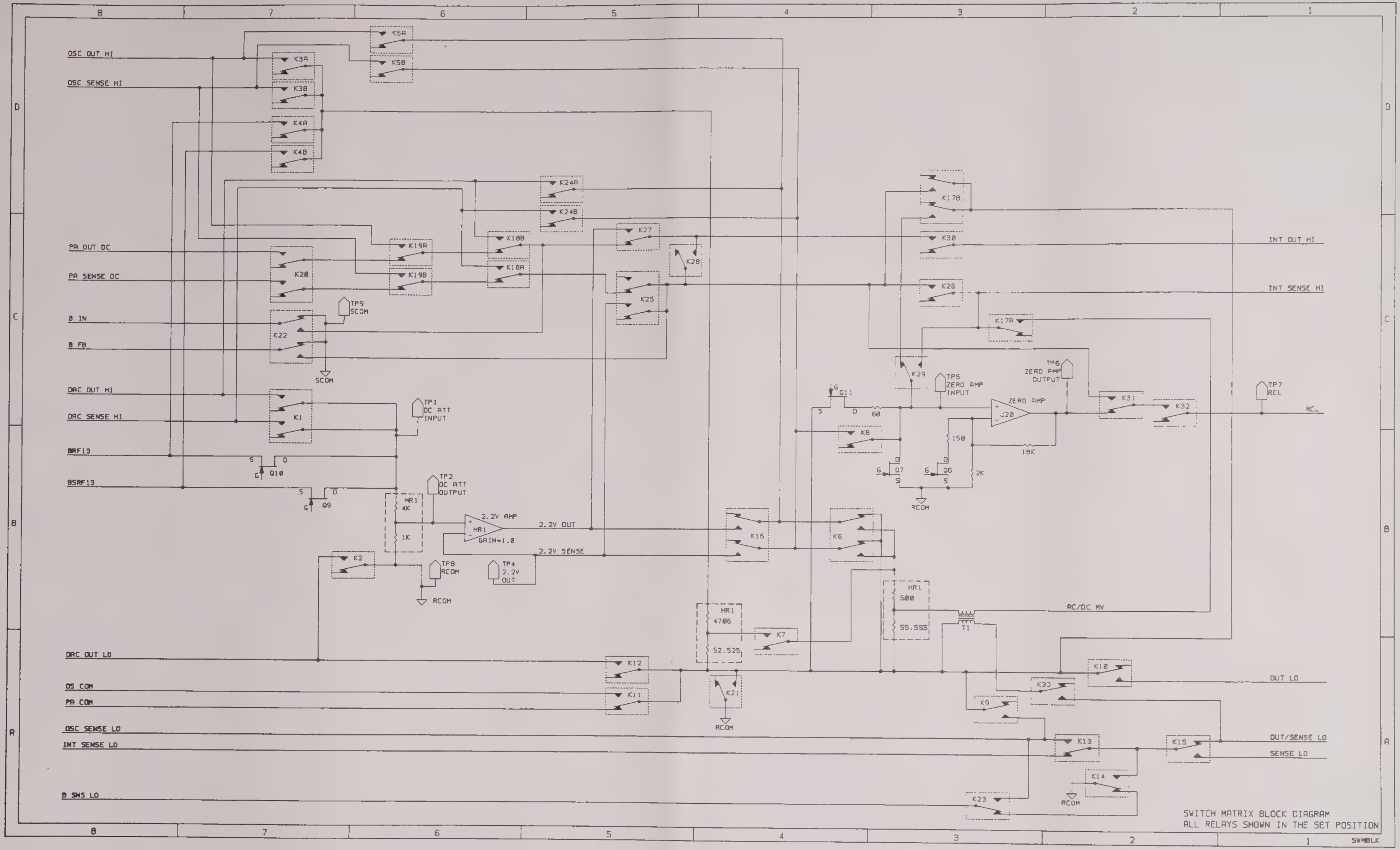


Figure 2-7. Switch Matrix Assembly Simplified Schematic

A UCN5801 driver (U13) drives non-latching relays on the motherboard. The motherboard non-latching relay supply circuit, as outlined in sections A6 through A8 of the schematic diagram, contains U17, Q1, Q2, CR1, CR2, CR10, and R6-R12. Port A of U1 provides data for this driver (PA0-PA7), and decoder U2 provides the strobe signal. Since this driver controls non-latching relays, the enable is tied to LH COM.

The non-latching relay supply circuit provides approximately 7V to the relays on the motherboard during pull-in, and approximately 3.5V during normal operation. This voltage is routed to the motherboard on the RLY+V line. The 7V is needed to ensure pull-in while the 3.5V is sufficient to prevent drop out. This cuts relay heating and thermal EMFs. PC5 controls the non-inverting amplifier U17. This amplifier is the control element for Transistor Q1. When PC5 is low, the output is 3.5V, and when PB5 is high, the output is 7V. Components CR1, Q2 and R10-12 form a fold back current limit for the supply. The following steps are taken to select a particular state for Motherboard relays RLY1-RLY10:

1. Write the data corresponding to the desired state to port A(PA0-PA7) of the 82C55 (U1).
2. Strobe the data into U13 by writing 8 hex to PB0-PB3 to make U13STB go high, then a 9 hex to make it go low.
3. Apply 7V to the relay coils by setting PC5 high.
4. Wait approximately 20 ms for the relays to pull in, then reduce the coil voltage to 3.5V by setting PC5 low.

There are five FETs on the Switch Matrix. Q9 and Q10 (sheet 3, C7), which are N-channel JFETs controlled by port B (PB5) of U1, are driven by an LM393 open-collector comparator (U15A) to provide the proper level shifting. DMOS enhancement FETs are used for the remaining three FETs (Q6, Q7, and Q11). Refer to sheet 1, B5 of the schematic diagram. FETs Q6 and Q7 are driven by U1, port B, with a high on PB4 turning on Q6, and a logic high on PB7 turning on Q7. FET Q11 is driven on by a logic high from U1, port C (PC4).

The diagnostic circuit (sheet 4, B7) enables the calibrator to monitor +8RLH, the 2.2V range output voltage, +5RLH, -5LH, +17S, -17S, the assembly temperature (U3), and the OVEN TEMP line from the heated hybrid. OVEN TEMP, +5RLH, -5LH, and +8RLH are divided down by a factor of 11 by Z5 and Z6. A 4051 analog multiplexer (U4) is controlled by PA0-PA2 and PC6 from U1. This multiplexer selects which one of these eight voltages is applied to the SDL line, where it is measured by the adc circuit on the DAC assembly (A11).

Switch Matrix Operation: 11V DC and 22V DC Ranges *2-89.*

Refer to Figure 2-8 for the following discussion. DC 11V and 22V ranges are generated by the DAC assembly and routed directly to the front panel binding posts through relays on the Switch Matrix and Motherboard.

Line DAC HI is connected to INT OUT HI through relays K18B, K27, and K30. INT OUT HI is connected to the OUTPUT HI binding post through relay K1 on the motherboard. Line DAC SENSE HI is connected to INT SENSE HI through relays K18A, K25, and K26. Motherboard relays K2 and K3 switch INT SENSE HI to the SENSE HI binding post during external sensing, or OUTPUT/SENSE HI during internal sensing.

Lines PA COM and DAC LO are connected by relays K11 and K12, and connected to the OUTPUT LO binding post by relay K10. Switch Matrix relays K14 and K15 connect R COM to the SENSE LO binding post during external sensing, or to OUTPUT/SENSE LO during internal sensing.

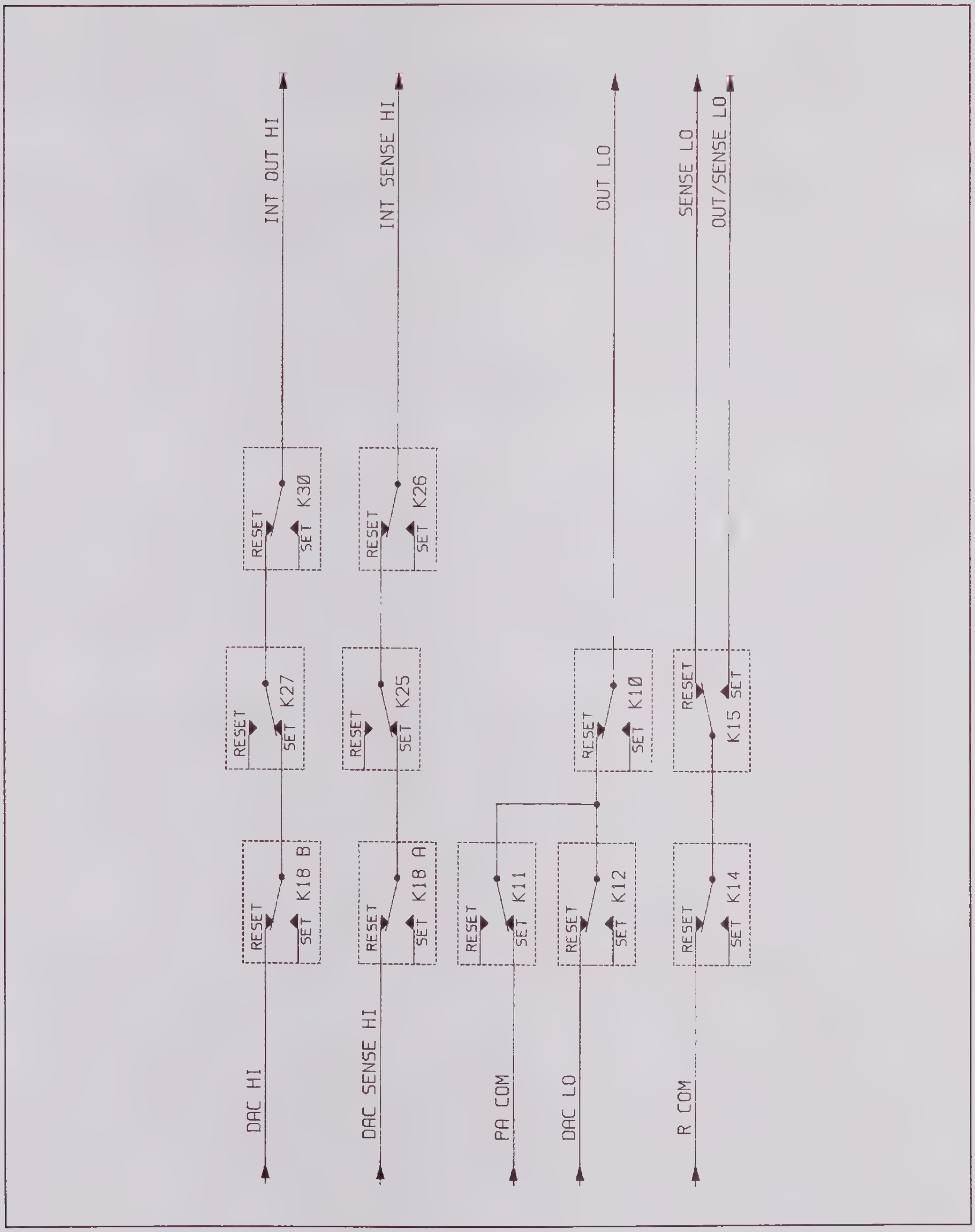


Figure 2-8. Switch Matrix Configuration for 11V DC and 22V DC Ranges

Switch Matrix Operation: 2.2V AC and 22V AC Ranges *2-90.*

Refer to Figure 2-9 for the following discussion. AC 2.2V and 22V ranges are generated by the Oscillator assemblies and routed directly to the front panel binding posts through relays located on the Switch Matrix and Motherboard.

Line OSC OUT is connected to INT OUT HI through relays K19A, K18B, K27, and K30. INT OUT HI is connected to the OUTPUT HI binding post through relay K1 on the motherboard. Line OSC SENSE is connected to INT SENSE HI through relays K19B, K18A, K25, and K26. Motherboard relays K2 and K3 switch INT SENSE HI to the SENSE HI binding post during external sensing, or OUTPUT/SENSE HI during internal sensing.

Line OSC COM is connected to the OUTPUT LO binding post through relays K11 and K10 on the Switch Matrix. Switch Matrix relays K13 and K15 connect OSC SENSE LO to the SENSE LO binding post during external sensing, or OUTPUT/SENSE LO during internal sensing.

Switch Matrix Operation: 220V AC and DC Ranges *2-91.*

Refer to Figure 2-10 for the following discussion. In the dc 220V range, PA OUT HI from the Power Amplifier assembly (A16) is routed to the High Voltage Control assembly (A14), where it goes through relay K10 and becomes PA OUT DC. Line PA OUT DC is routed to the Switch Matrix and connected to INT OUT HI through relays K20, K19A, K18B, K27 and K30. Relay K1 on the motherboard connects INT OUT HI to the OUTPUT HI binding post.

Line PA SENSE DC is connected to INT SENSE HI through relays K20, K19B, K18A, K25, and K26. Motherboard relays K2 and K3 switch INT SENSE HI to the SENSE HI binding post during external sensing, or OUT/SENSE HI during internal sensing. PA COM and DAC LO are connected by relays K11 and K12, and connected to the OUTPUT LO binding post by relay K10. Switch Matrix relays K14 and K15 connect R COM to the SENSE LO binding post during external sensing, or OUTPUT/SENSE LO during internal sensing.

In the ac 220V range, Power Amplifier outputs PA OUT HI and PA SNS AC are routed to the High Voltage Control assembly (A14) where relays K10, K3, and K13 connect them to HV OUT and HV SNS respectively. HV OUT is connected to the OUTPUT HI binding post through relays K9 and K1 on the motherboard. Motherboard relays K10, K2, and K3 connect HV SNS to the SENSE HI binding post during external sensing, or to OUTPUT/SENSE HI during internal sensing. Connection to the OUTPUT LO and SENSE LO binding posts is done with relays on the Switch Matrix. PA COM is connected to the OUTPUT LO binding post through relays K11 and K10. Switch Matrix Relays K13 and K15 connected OSC SENSE LO to the SENSE LO binding post during external sensing, or OUTPUT/SENSE LO during internal sensing.

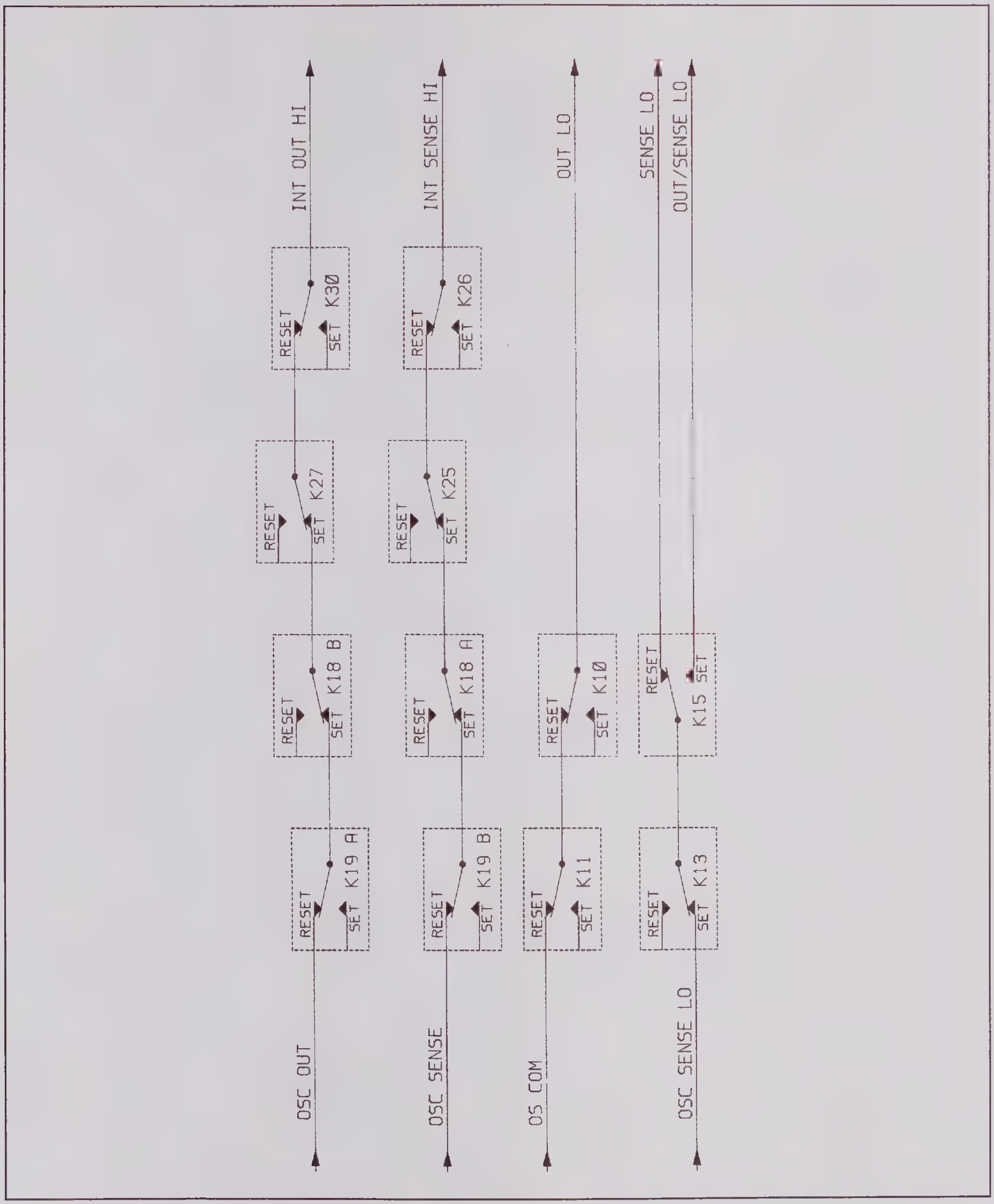


Figure 2-9. Switch Matrix Configuration for 2.2V and 22V AC Ranges

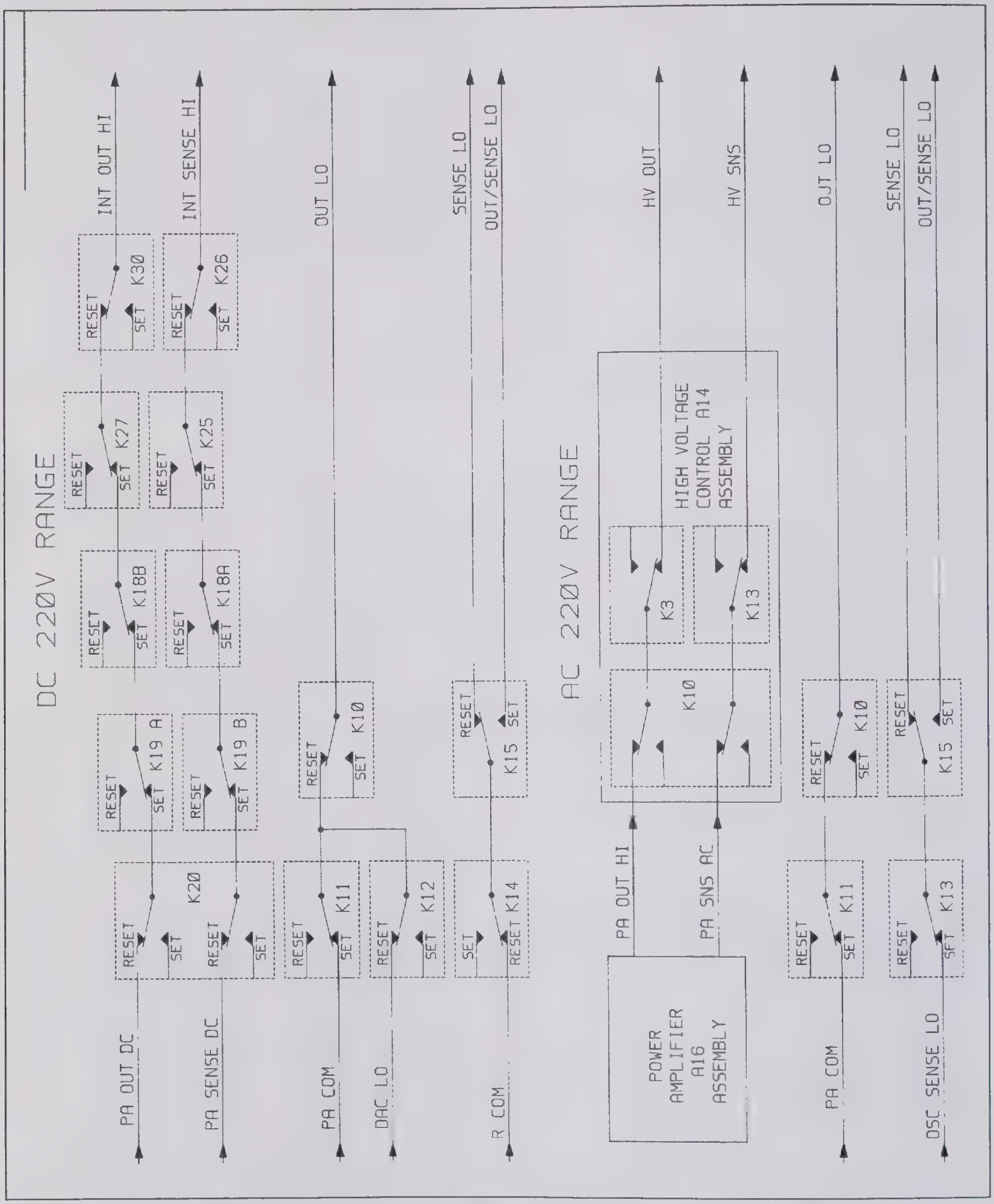


Figure 2-10. Switch Matrix Configuration for 220V DC and AC Ranges

Switch Matrix Operation: 2.2V DC Range *2-92.*

Refer to Figure 2-11 for the following discussion. The dc 2.2V range circuit consists of the dc 2.2V attenuator and a dc 2.2V range amplifier as outlined on sheet 3 of the Switch Matrix schematic. This circuit contains a CA3096 transistor array IC (U19A-E), transistor Q4, FETs Q12 and Q13, resistors R20, R23-R30, and R32, relays K1 and K2, part of the resistor network 4R07, and a dc amplifier heated hybrid.

The resistor network is bonded to the hybrid and this entire assembly is called the 5700A-4HR1 (HR1) on the schematic. Transistor Q3 drives the heater resistor on the hybrid. The heater control circuit adjusts the base voltage of Q3 to deliver the correct power to the heater resistor to maintain thermal control. Transistor Q8 protects the hybrid in case Q3 fails.

To produce the dc 2.2V range, the DAC assembly (A11) is set to the 11V range. DAC OUT HI and DAC SENSE HI are connected to pin 10 of the resistor network by relay K1, and DAC LO is connected to pin 9 by relay K2. The network divides the voltage by five. The divided voltage from pin 8 is connected to the input (pin 11) of the dc amplifier hybrid.

This temperature-controlled amplifier is used as a buffer amplifier. The output of the buffer amplifier (pin 18) drives the 2.2V range high current output stage consisting of U19, Q4, R25-R30, R32, and CR7-CR9. This circuit enables the 2.2V range to support 50 mA of current with current limiting. FETs Q12 and Q13 provide localized feedback for the precision dc amplifier during unusual conditions, such as a short circuit at the OUTPUT binding posts or when this range is in standby.

Line 2.2V OUT is connected to INT OUT HI through relays K27 and K30 on the Switch Matrix. Line INT OUT HI is connected to the OUTPUT HI binding post through relay K1 on the motherboard. Line 2.2V SENSE is connected to INT SENSE HI through relays K25 and K26 on the Switch Matrix. Motherboard relays K2 and K3 switch INT SENSE HI to the SENSE HI binding post during external sensing, or to OUTPUT/SENSE HI during internal sensing.

Line PA COM is connected to the OUTPUT LO binding post through relays K11 and K10. Switch Matrix relays K14 and K15 connect R COM to the SENSE LO binding post during external sensing, or OUTPUT/SENSE LO during internal sensing.

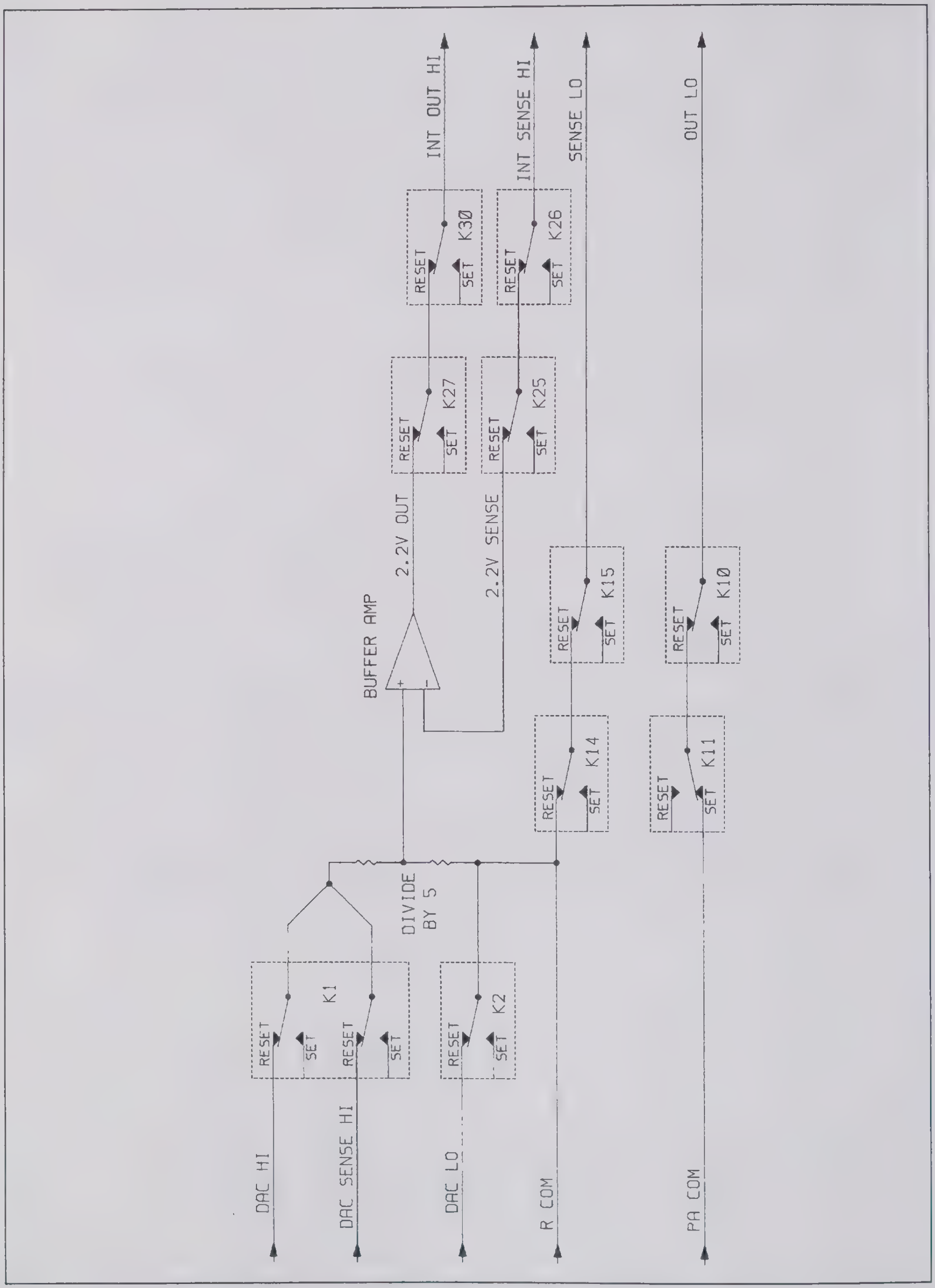


Figure 2-11. Switch Matrix Configuration for 2.2V DC Range

Calibration of the 2.2V Range *2-93.*

Refer to Figure 2-12 for the following discussion. Calibration of the 2.2V range involves determining its offset and gain constants.

To calibrate the offset:

1. The gain of the internal cal zero amplifier is set to 130 by turning on Q6 via PB4.
2. A checkpoint reading is taken, which represents 0V at the input of the internal call zero amplifier. In this configuration, PBS turns on FET Q7 connecting RCOM to the internal cal zero amplifier input, K29 is open (set position), and the output of the cal zero amplifier is connected to RCL via relays K31 and K32.
3. The input of the internal cal zero amplifier is connected to the output of the 2.2V range. The 2.2V range is adjusted until the adc reads the same as the checkpoint reading within the given tolerance. In this configuration, 2.2V OUT and 2.2V SENSE are tied together by relay K28 and the output (NIT SENSE HI) of the range is channeled into the internal cal zero amplifier input (sheet 1) through relay K29.

To calibrate the gain of the 2.2V range, the 13V buffered reference (BRF13 and BSRF13) from the DAC assembly (A11) is connected to the input of the 2.2V range by FETs Q9 and Q10 on sheet 3 of the schematic. Since this network divides the voltage by five, a voltage of 2.6V is obtained at the 2.2V OUT and 2.2V SENSE points. These points are tied together by relay K28. This voltage is then channeled to the RCL line by relays K31 and K32 where it is connected to the +input of the adc amplifier on the DAC assembly (A11). The DAC output is connected to the -input of the adc amplifier and is adjusted until a null is achieved. At this point, the DAC voltage represents the output voltage of the 2.2V range. Gain is determined since the output, input, and offset of the 2.2V range are now known.

Switch Matrix Operation: 220 mV DC Range *2-94.*

Refer to Figure 2-13 for the following discussion. The 220 mV range is an extension of the dc 2.2V range. The 2.2V range is divided by ten to produce the 220 mV range. This 10:1 divider (on sheet 2 of the Switch Matrix Schematic) is part of the resistor network on the 4HR1 assembly.

The 220 mV range is passive with an output resistance of 50Ω. This range is generated by connecting the 2.2V OUT and 2.2V SENSE to pin 3 of the 10:1 divider by relays K16 and K6. Lines PA COM and R COM are connected to pin 2 of the 10:1 divider by relays K11 and K21. This divided output from pin 1 is called AC/DC mV on the schematic. This portion of the resistive attenuator is also used for generating the ac 2.2 mV and 22 mV ranges. The AC/DC mV signal is then connected to INT SENSE HI through relay K17A on sheet 1 of the Switch Matrix schematic. Line INT SENSE HI is connected to the OUTPUT HI binding post through relays K2 and K3 on the motherboard. Sensing for the LO occurs by connecting R COM and PA COM via K11 and K21. A single line is run out to the OUTPUT LO binding post by relay K33 on the Switch Matrix.

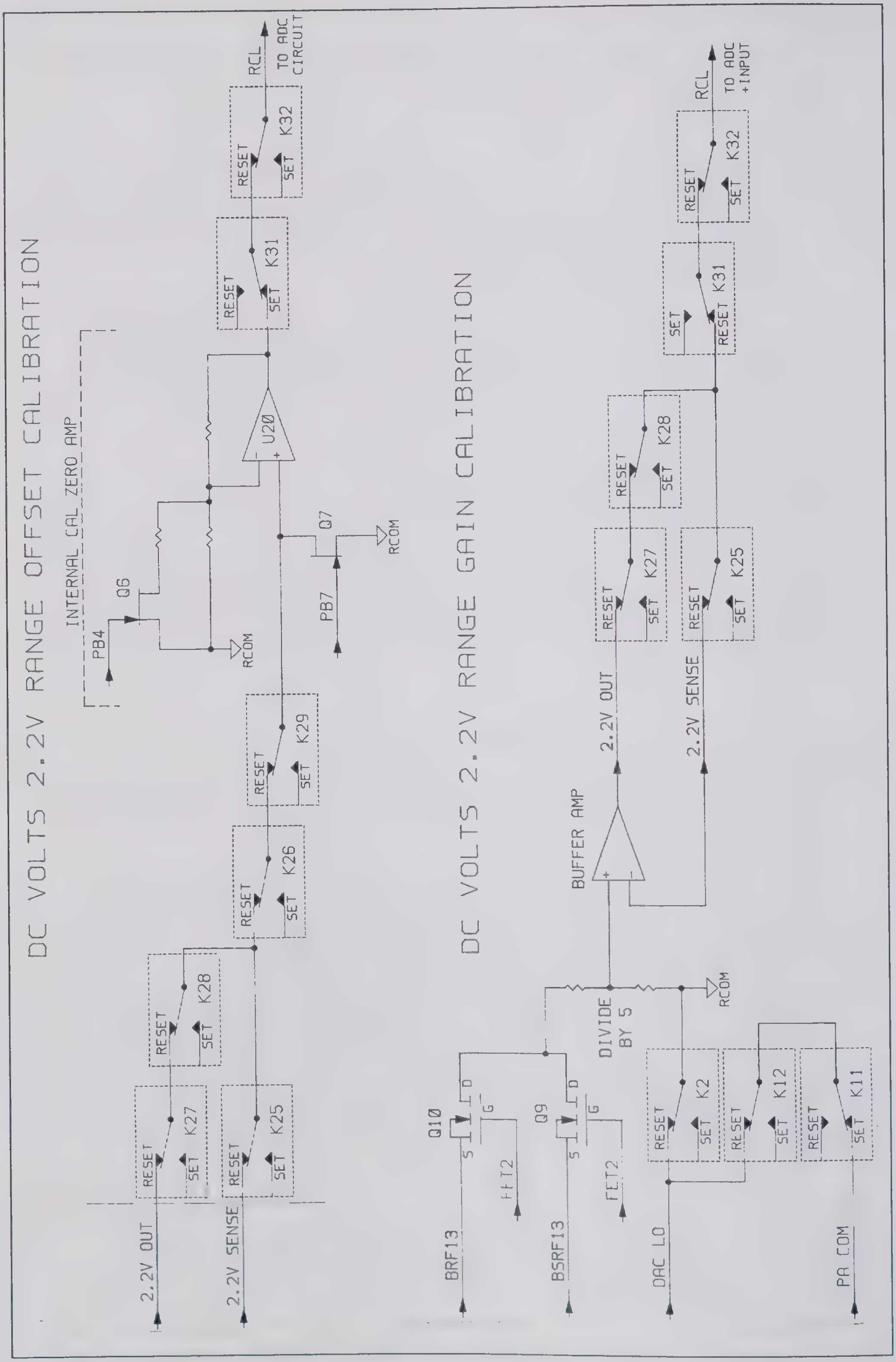


Figure 2-12. Calibration of the 2.2V DC Range

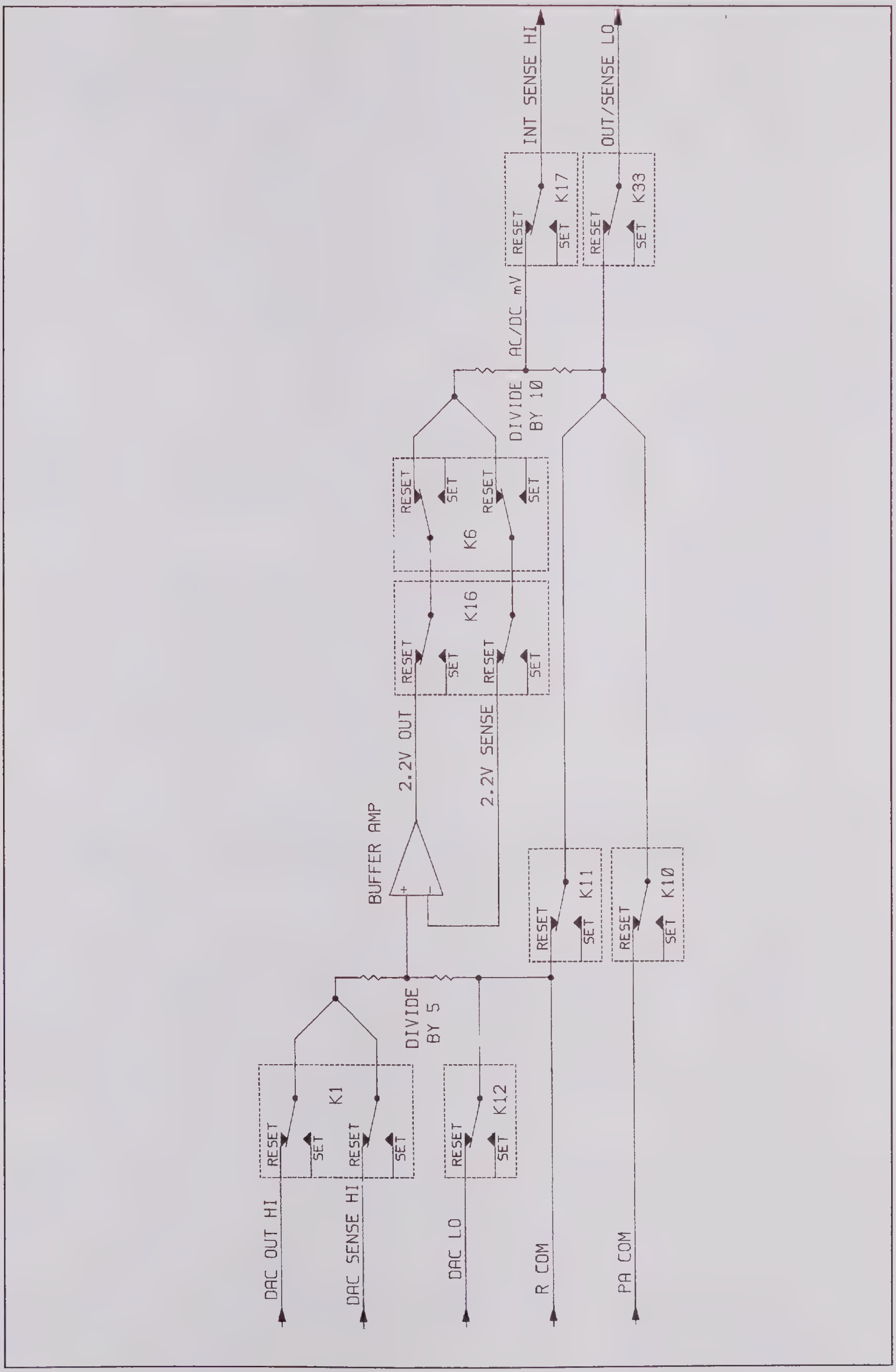


Figure 2-13. Switch Matrix Configuration for 220 mV DC Range

Switch Matrix Operation: 220 mV AC Range 2-95.

Refer to Figure 2-14 for the following discussion. As previously mentioned, the ac 220 mV range uses the same resistor network as the dc 220 mV range. In generating the ac 220 mV range the Oscillator assembly is set to the 2.2V range. Lines OSC OUT and OSC SENSE are connected to pin 3 of the 10:1 divider by relays K5 and K6. Lines OS COM and OSC SENSE LO are connected to pin 2 by relays K11 and K9 respectively.

This divided output from pin 1 is referred to as AC/DC mV on the schematic. The AC/DC mV is then connected to INT SENSE HI through relay K17 on sheet 1 of the Switch Matrix schematic. Signal INT SENSE HI is connected to the OUTPUT HI binding post through relays K2 and K3 on the motherboard. Sensing for the LO occurs by connecting OS COM and OSC SENSE LO via K11 and K9. A single line is run out to the OUTPUT LO binding post by relay K33 on the Switch Matrix.

Switch Matrix Operation: 2.2 mV and 22 mV AC Ranges 2-96.

Refer to Figure 2-14 for the following discussion. The ac 2.2 mV and 22 mV ranges use the 100:1 divider and the 10:1 divider of resistor network on 4HR1 for a total division of 1000:1. Switch Matrix operation for these two ranges is the same. For the 2.2 mV range, the Oscillator assembly is set to the 2.2V range. For the 22 mV range, the Oscillator assembly is set to the 22V range.

Signals OS COM and OSC SENSE LO are connected to pin 6 of the 100:1 divider and pin 2 of the 10:1 divider by relays K11 and K9. OSC OUT and OSC SENSE are connected to the input (pin 7) of the 100:1 divider by relay K3 (A and B). The output of this 100:1 divider is then connected to the input of the 10:1 divider (pin 3) by relay K7. At the output of the 10:1 divider (called AC/DC mV on the schematic) there is a total division of 1000:1. Connection to the binding posts is done in the same manner as in the ac 220 mV range. In all cases, the output impedance of the millivolt ranges is 50Ω.

Calibration of the mV Ranges 2-97.

Calibration of the mV ranges involves determining the resistor ratios of the 10:1 divider and the 1000:1 divider (100:1 and 10:1 dividers cascaded). In addition, an offset calibration is performed on the 10:1 divider to remove thermal EMF error for the 220 mV dc range.

Refer to Figure 2-15 for the following discussion. The 10:1 divider offset is calibrated by configuring the Switch Matrix for the 220 mV dc range, except with the output of the range (AC/DC mV) switched into the input of the internal cal amplifier through relays K17 and K29. The Calibration procedure is the same as described for the 2.2V range offset calibration except that during a checkpoint reading, control line PC4 turns on Q11 which connects SWM SENSE LO to the input of the zero amplifier, representing 0V for the 220 mV range.

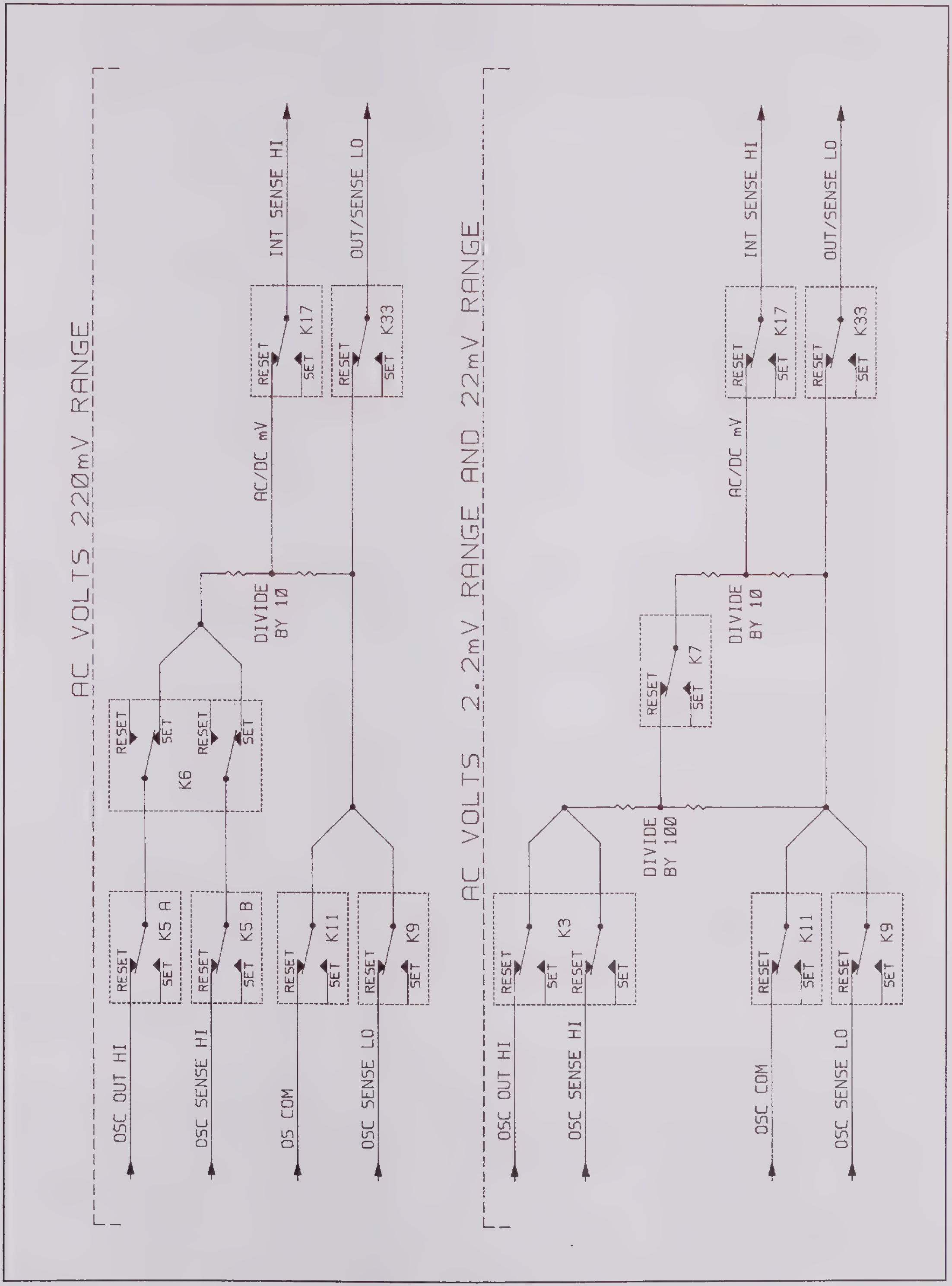


Figure 2-14. V AC, 2.2 mV AC, and 22 mV AC Range

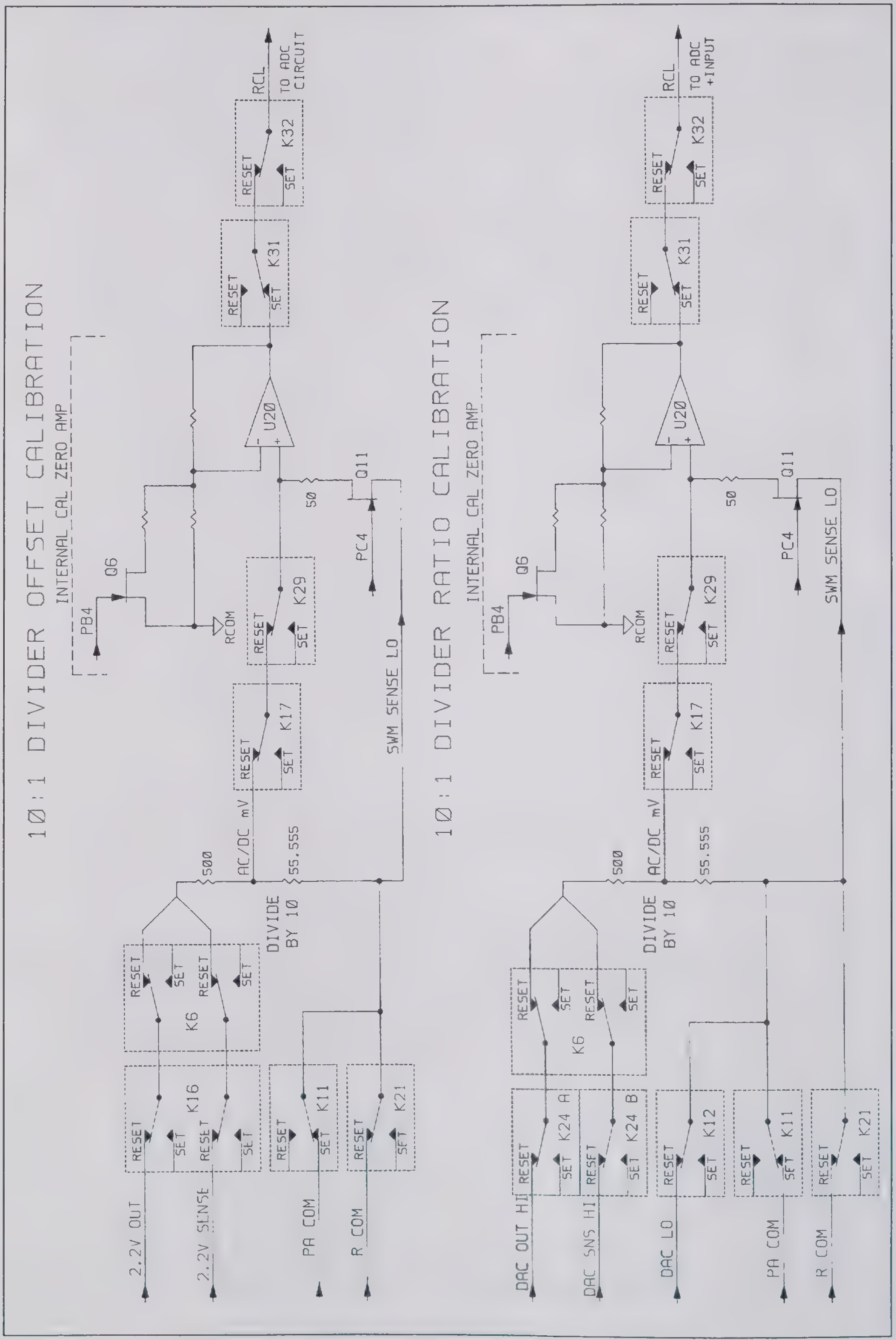


Figure 2-15. Divider Calibration

Calibration of the 10:1 divider ratio is accomplished by connecting the DAC assembly output (DAC OUT HI and DAC SENSE HI) through relays K24 (A and B) and K6 to the input of the 10:1 divider. DAC LO, PA COM, and R COM are connected to the common of the 10:1 divider by relays K12, K11, and K21 respectively. The DAC output is set to 2.2V to produce approximately 0.22V at the output of the 10:1 divider (AC/DC mV). Relays K17 and K29 direct this voltage to the internal cal zero amplifier, which is configured for a gain of 10, giving 2.2V plus an unknown error at its output.

The equation for this output is the DAC output (2.2V) multiplied by the 10:1 divider ratio (unknown) multiplied by the internal cal zero amp gain (calibrated, approximately 10). Once the output of the internal cal zero amplifier is determined, the 10:1 divider ratio is the only unknown, so it can be calculated.

To determine the output of the internal cal zero amplifier for this configuration, a checkpoint reading is first taken by connecting both inputs of the DAC's adc amplifier to the DAC output, which is set to 2.2V. This reading represents a null at 2.2V. The output of the internal cal zero amplifier is then channeled to the RCL line by relays K31 and K32 and to the +input of the adc amplifier on the DAC assembly with the DAC output still connected to the -input. An adc reading is now taken and the checkpoint reading is subtracted from it. This value is the adc's representation of the deviation of the internal cal zero amplifier output from 2.2V.

However, due to inaccuracy in the adc, an additional step must be taken. The -input of the adc amplifier is connected to RCOM and the +input to the DAC output. The DAC output is adjusted until the adc reads the previous value within the given tolerance. At this point, the DAC output voltage represents accurately the deviation of the internal cal zero amplifier output from 2.2V. The output of the internal cal zero amplifier is now calculated, allowing the 10:1 divider ratio to be determined.

Refer to Figure 2-16 for the following discussion. Calibration of the 100:1 divider ratio is similar to calibration of the 10:1 divider ratio. The 13V buffered reference (BRF13 and BSRF13) is connected to the input of the 100:1 divider pin 7 by relay K4 (A and B). DAC LO, PA COM , and R COM are connected to pin 6 of the 100:1 divider by relays K12, K11, and K21 respectively. The voltage at the divider output (pin 5) is approximately 0.13V. Relay K7 connects the output of the 100:1 divider to the input of the 10:1 divider. Relays K6 and K8 connect it to the ac mV CAL line, which is the input to the internal cal zero amplifier. The result is 1.3V at the amplifier output. This voltage is switched onto the RCL line by relays K31 and K32 to the DAC assembly, where the DAC is nulled to it. At this point, the DAC voltage represents the internal cal zero amplifier output and the 100:1 divider ratio is calculated.

Internal CAL Zero Amplifier *2-98.*

The main function of the internal cal zero amplifier is to remove the offsets of each of the dc ranges except the 1100V range. (The 1100V dc range is zeroed at the High Voltage/High Current assembly.) The internal cal zero amplifier is switched into two gain configurations for range zeroing; a gain of 130 for the 22V ranges and below, and a gain of 10 for the 220V range. Each range is channeled into the internal cal zero amplifier via relay K29. The range is then compared against 0V by connecting R COM to the amplifier via FET Q7. For the 220 mV range, the reading for 0V (or checkpoint reading) is taken by turning on Q11 instead of Q7 in order to achieve a 50Ω impedance. The output of the amplifier is connected to the RCL line by relays K31 and K32, and then channeled to the DAC assembly where the signal is measured by the adc.

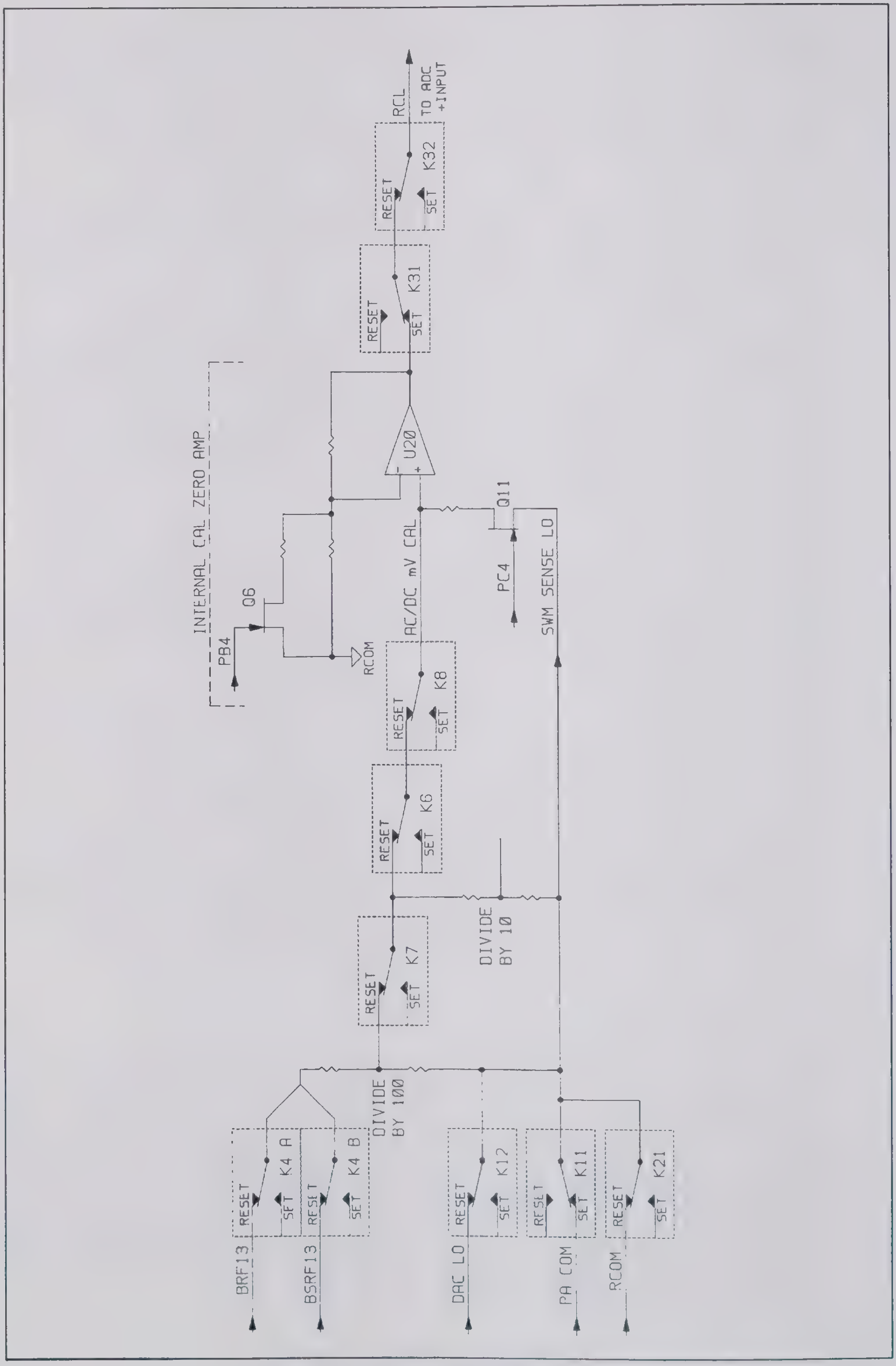


Figure 2-16. Divider Gain Calibration

The internal cal zero amplifier is outlined in a broken line rectangle on sheet 1 of the schematic. Its functional parts are U20-U21, R38-44, R46-47, Q6-7, Q11, and Z2. When Q7 is on, the input of the zero amplifier is connected to 0V for a reference point. When Q6 is on, the gain of the zero amplifier is 130. Op amp U21 and its associated resistors form a current-cancellation circuit. It senses the output of the zero amplifier and creates a current equal in magnitude but opposite in polarity to the current through the gain resistors (Z2), resulting in zero current in the precision common (RCOM).

Switch Matrix 5725A Amplifier Interface *2-99.*

The Switch Matrix also provides switching between the calibrator and the 5725 Amplifier. The ac and dc input signals necessary to operate the 5725A are connected by relay K22. Relay K23 connects B SNS LO to either OSC SENSE LO or R COM via relay K14.

DAC Assembly (A11) *2-100.*

The DAC (digital-to-analog converter) is the basic building block of the calibrator. Other assemblies create ac and dc voltages and currents with its precision dc voltage. The DAC contains five assemblies:

- DAC Main Board (A11)
- DAC Filter SIP (A11A1)
- DAC Buffered Reference SIP (A11A2)
- Reference Hybrid (HR5)
- DC Amplifier Hybrid (HR6).

The DAC assembly serves two main functions:

- To provide a highly repeatable stable dc voltage
- To support calibration of the calibrator

The DAC's adc circuit is used to accomplish calibration. It is made up of an analog to digital converter (adc) and the adc amplifier. Together, these are used to completely characterize the calibrator, using only one external voltage source and two external resistor standards.

Basic DAC Theory of Operation *2-101.*

Figure 2-17 is a simplified schematic of the DAC assembly. The DAC uses a pulse-width-modulated scheme to produce a precision dc voltage of 0V to 22V with positive and negative polarity. The DAC contains:

- A 13V temperature-controlled reference hybrid (HR5)
- Duty-cycle control circuitry
- A five-pole active filter (A11A1 assembly)
- An output stage
- Digital control circuitry
- These basic subcircuits work together for a stable and linear dc voltage.

The DAC assembly also contains:

- A sense-cancellation circuit
- Linearity control circuits
- Negative offset circuit
- An output switching circuit

The two inputs of the five-pole filter are two precision square waves with different fixed amplitudes and independently variable duty cycles controlled by software. The filter's first input square wave is called the first channel. It is switched between the reference voltage (13V) and 0V.

The filter's second input square wave is called the second channel. It is switched between approximately 0.78 mV and 0V. Its amplitude is derived by resistively dividing the 13V reference. This second channel is used for extra resolution.

The filter rejects all ac components of the waveforms above 10 Hz. Since the frequency of the square waves is 190 Hz, the output of the filter is a dc voltage which is the sum of average voltages of the two waveforms. The Output Stage, which consists of the dc amplifier hybrid and the output buffer, isolates the filter output from the DAC output and gives current drive to the DAC output.

The output stage has a current limit of approximately 60 mA. It can be configured for a gain of one for the 11V range, or a gain of two for the 22V range. Relays on the DAC output lines allows them to be inverted for negative polarity.

To change the DAC voltage, the average value of the two square waves must be varied. To determine the average value, multiply the waveforms amplitude by its duty cycle. Vary the duty cycle and keep the amplitude fixed to change the DAC voltage.

For example, if the duty cycle of the first channel is 10% and the second channel 50%, the overall average voltage would be:

(0.1 x 13V) + (0.5 x 0.78 mV) = 1.300390V.

The duty cycle resolution is 0.0024%, which gives a first channel resolution of 0.309 mV and second channel resolution of 18.5 nV.

The duty cycle control circuitry creates the two digital square waves for the first and second channels. These two waveforms are first run through optocouplers for isolation and then into analog switching and level shifting circuits. These circuits derive the proper signals to switch the input of the filter at the levels explained above.

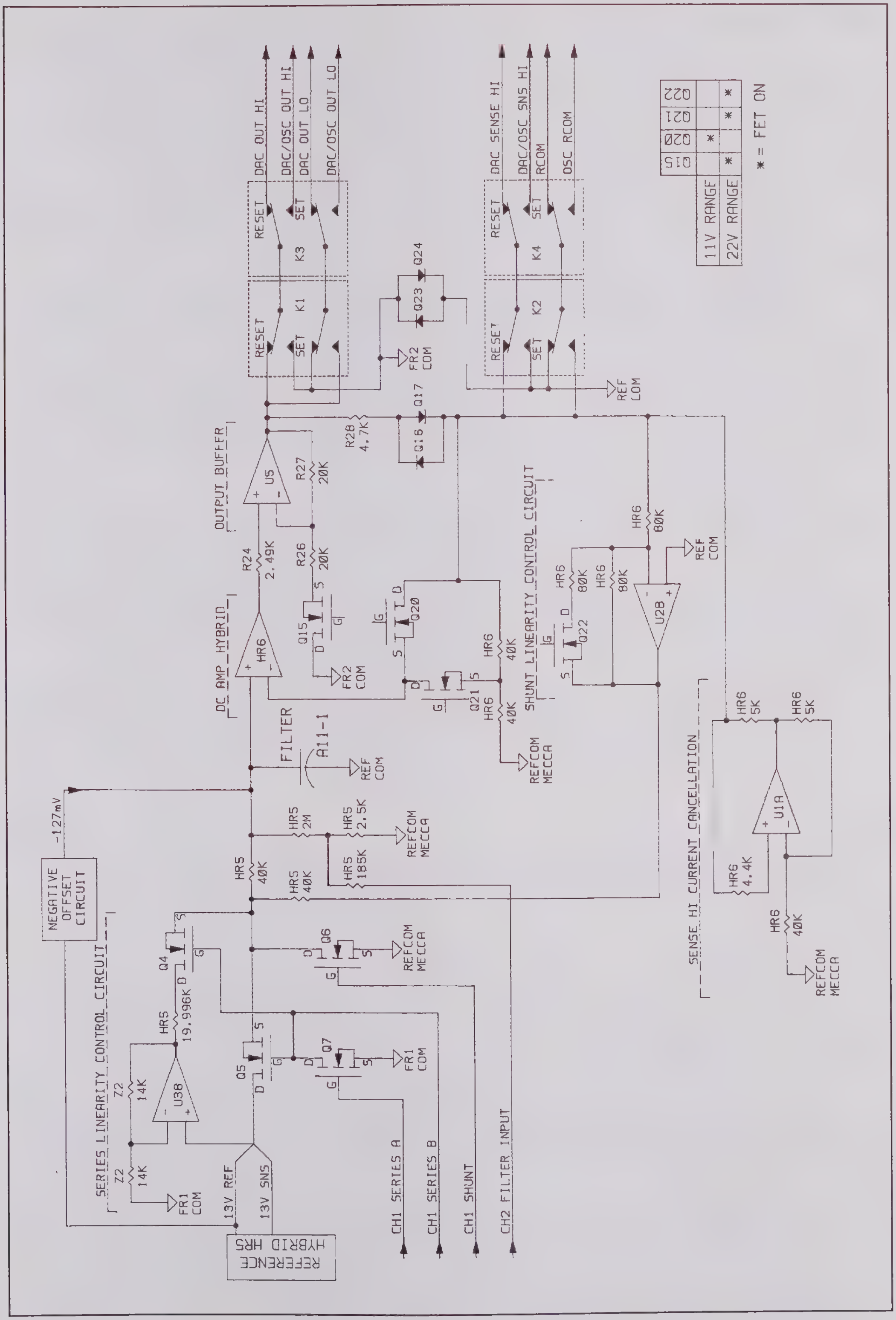


Figure 2-17. DAC Assembly Simplified Schematic

DAC Assembly Digital Control 2-102.

The digital control circuit is located on sheet 6 of the DAC schematic. The 82C55 Programmable Peripheral Interface IC (U31) is the heart of this circuit.

This IC, which is under software control via the guarded digital bus, has three ports that provide 24 static lines. Port A (PA0-PA7) is configured as a read-only port register. It passes the adc readings from the ADC IC (U25) to the guarded digital bus.

PB0-PB4 of port B control relays K1-K4 and K6-K8 via relay drivers U33 and U34. PB0 is also control line DAC OUT SEL used to turn on FET Q25, via FET Q26, and connect RCOM to SCOM during calibrator operation in the ac function.

PC7 of port C, buffered by U8A, provides the enable for these relay drivers. Relay driver U33 controls latching relays K7 and K8. Outputs from U33 are also used by Relay driver U34 to control latching relays K1-K6. PB5-PB7 are decoded by U32 to create six control lines. These control lines are used to select one input to the adc amplifier -input. K5SEL is an input to the relay drivers to control latching relay K5. The remaining five control lines are used by comparators in U35 and U36. These comparators provide the proper level shifting to create control lines BSRF6 SEL, BSRF13 SEL, REF6 SEL, REF13 SEL, and ADC COM SEL. These control lines are used to control FETs on the DAC Buffered Reference SIP assembly (A11A2).

PC0 of port C is buffered by U8 (B and C) and routed through opto-isolator U37 to create RANGE SELECT, which sets the DAC to the 11V or 22V range. PC1 is used in the duty cycle control circuit to shut off the 8 MHz clock via buffer U8F and the first channel via OR gate U9D. This is done during calibrator operation in the resistance function. PC2 controls a FET in U23 for use in self-diagnostics. PC3 and PC4 are level-shifted by comparators in U36 before they are used to control FETs in U23. PC5 of port C is connected to a comparator in U36. This comparator provides the proper level shifting to create control line ADCAMP OUT SEL to control a FET in U23. PC6 is control line ADC TRIGGER which triggers the adc (analog-to-digital converter) IC U25. A0, A1, and CS*, from the guarded digital bus, are used by OR gates in U9 (B and C) to create control line ADC READ for use by the adc IC U25.

DAC Assembly Reference Circuitry 2-103.

The reference circuitry is on the reference hybrid, located on the HR5 assembly. The HR5 assembly contains a ceramic substrate reference hybrid bonded to a resistor network.

All components on this assembly are surface mount devices, except U6 and U7. The resistors are screened with a thick film paste. Associated resistors, capacitors, and zener diodes are mounted on the main board to supply this hybrid with the appropriate power and ground returns.

As previously explained, the amplitudes of the pulse width modulated signals for the first and second channel are assumed to be fixed. Any change in amplitude shows up as an error on the output of the DAC. Since the reference is used to determine the amplitude, it must be very stable and generate little noise.

The 13V reference contains two cascaded 6.5V temperature compensated transistor/zener diode pairs called ref amps (U6 and U7). The excellent temperature characteristics of the ref amps are obtained by biasing the collector current on their transistors with a value such that the TC (temperature coefficient) of its base-emitter junction cancels the TC of the zener diode. Since the base-emitter junction and the zener diode are in series, the result is a near zero TC.

Correct bias currents are achieved with a thin-film resistor network in a surface-mount package mounted on the hybrid.

The reference circuit is designed such that the effects of the thin-film resistors and op amp errors are second order. Thus, accuracy is determined almost entirely by the ref amps.

To further reduce the effects of ambient temperature variations, the hybrid is heated to a constant 62°C by the heater control circuitry on sheet 1 of the DAC schematic.

Temperature is sensed near the ref amps by a thermistor (RT1). If the substrate temperature changes, the thermistor resistance changes. This creates a correction voltage to the base of Q2 (on the main board). This, in turn, causes the power into the heater resistor, which is screened on the back of the substrate, to increase or decrease as necessary to maintain a stable temperature.

Thermal runaway is prevented by a protection circuit. Once the substrate temperature reaches approximately 67°C, the change in resistance of RT2 causes Q9 to turn on. As transistor Q9 turns on, it steals base current from Q1 on the main board, which brings it out of saturation. This breaks the current path through the heater resistor. This condition exists only if there is a failure.

The exact value of the reference is determined during calibration. Because of the stability of the reference, it can be used for future internal calibration procedures to remove short term errors in the calibrator.

The 13V output, REF13 HI, is from pin 9 and REF13 SENSE is on pin 12. Also, a 6.5V reference line, REF6, is brought out on pin 14 of the reference for use during calibration.

In order to make these reference voltages available to other assemblies, the 6.5V and 13V references are buffered on the DAC Buffered Reference SIP assembly (A11A2). This assembly also contains the circuitry to switch the references and buffered references into the input of the adc during calibrator calibration. Refer to the section on the DAC Buffered Reference SIP for more information.

Duty-Cycle Control Circuit *2-104.*

Duty-cycle control circuitry is pictured on sheet 3 of the schematics. DAC output voltages are represented in software by what are called first and second channel counts. Each count is a 16-bit number which is sent to the DAC assembly via the guarded digital bus.

For example, a first channel count of 20,000 (in decimal) represents a DAC output voltage of approximately 6.5V (half the reference voltage).

The first function of the duty-cycle control circuitry is to convert each count into a stable, TTL level, square wave, with a duty cycle proportional to the numeric value of the count. This is accomplished with the 82C54 programmable interval timer (U6).

A low-level 8 MHz clock is generated on the Regulator/Guard Crossing assembly (A17) and routed to the DAC assembly via the motherboard. This low-level clock, CLK and CLK*, is amplified to a TTL level by comparator U7 to generate the 8 MHz clock which is used by U6 and the adc IC U25.

The 82C54 programmable interval timer receives its input counts from the guarded digital bus and creates the second channel signal on OUT2 (pin 20) and the first channel signal on OUT1 (pin 16).

The second channel signal is buffered by U8 (D and E) and runs through opto-isolator U12 to become CH2 FLOATING. This signal alternately turns FETs Q30 and Q32 on and off to turn the 3V source (called 3V) into a floating 3V pulse width modulated waveform called CH2 FILTER INPUT.

The 3V source is created from the 13V reference. The 13V reference is buffered by op amp U1B, configured as a voltage follower. The output from U1B is divided down to 3V by a 100 kΩ and 30 kΩ resistor in the HR5 assembly, creating 3V.

This 3V is again buffered by op amp U11, configured as a voltage follower, to create the 3V, which is switched by FETs Q30 and Q32. CH2 FILTER INPUT uses three resistors on the HR5 assembly to resistively divide its 3V amplitude by an additional factor of approximately 3800.

The first channel signal is buffered by U8 (G and H) and run through opto-isolator U13, to become CH1 FLOATING. Since the first channel is much more critical than the second, CH1 FLOATING is clocked into a flip flop (U14) to ensure an accurate waveform.

To clock in this waveform, the low-level 8 MHz clock (CLK and CLK*) from the Regulator/Guard Crossing assembly (A17) is isolated by transformer T1 and amplified to a TTL level by comparator U10. This generates the clock inputs for U14. The output Q1 (pin 5) from U14 creates CH1 SERIES A, which switches Q7. The output Q1* (pin 6) is inverted by Q35, creating CH1 SHUNT, which switches Q6. The output Q1*, which is a TTL level, is also amplified by components Q33, Q34, VR11, VR12, and R44-R46, so it switches from 0 to 18V, creating CH1 SERIES B, which switches Q4 and Q5.

The watchdog timer sets the first channel filter input to 0V if a failure occurs on the 8 MHz clock. This circuit uses a monostable multivibrator (one shot) U15, C63, and R48. The 8 MHz clock is divided to 4 MHz by U14. This 4 MHz clock is connected to U15 and discharges C63 to ground. If the 4 MHz clock stops, C63 charges up, causing the Q1 output of U15 to go low. This logic low on Q1 is connected to the preset pin of U14 (PRI), which causes its Q1 output high and its Q1* output low. This condition turns on the shunt switch and turns off the series switch, which forces the filter input to be REFCOM.

DAC Filter Circuit 2-105.

The dac filter circuit is located on the DAC Filter SIP (A11A1) assembly. The dominant pole of the filter is near 10 Hz. This gives 120 dB of rejection at 190 Hz.

The +30FR1 supply and 15V zener diode, VR1, create the 15V supply (15V) for the op amps in the filter circuit. 15V is also connected to the main DAC board, where it is used with R111 as a pull up for the RANGE SELECT control line.

DAC Output Stage 2-106.

The output stage of the DAC assembly consists of the DC Amplifier Hybrid assembly (HR6) and the output buffer circuitry. Like the Reference Hybrid, the DC Amplifier Hybrid is constructed of surface-mount components (except precision op amp U2), on a ceramic substrate hybrid, bonded to a resistor network.

It is temperature-controlled by a heater control circuit in the same manner as explained on the Reference Hybrid. Transistor Q3 provides proper power to the heater resistor.

The DC Amplifier Hybrid consists of a precision op amp U2, with a bootstrapped power supply (Q1, Q2, R1-R4, VR1-VR2). The op amp has low noise and low offset. It is bootstrapped to improve the common-mode rejection in its noninverting configuration.

The DC Amplifier assembly interfaces with the output buffer (U5) to create the output stage. Control line RANGE SELECT configures this output stage for unity gain for the

11V range or a gain of 2 for the 22V range. In the 11V range, Q15 is turned off, which gives U5 unity gain, and Q20 is on, which gives the DC Amplifier unity gain.

In the 22V range, Q20 is off and Q21 is on, which switches in the 40 kΩ feedback resistors located on the HR6 assembly. Precise ratio matching of these resistors provides high accuracy in the 22V range.

FET Q15 is on in the 22V range so that the output of the dc amplifier is half the output of the DAC. This is necessary so that the output of the dc amplifier is approximately the same as its inputs, which allows the bootstrap circuit to work.

The output buffer (U5) provides drive for the DAC output. It is used in a feedback loop with the DC Amplifier Hybrid so that the dc accuracy is dependent upon the dc amplifier, and the output drive capability is dependent on the output buffer.

The output buffer is current-limited to a short circuit current of about 60 mA. The short-circuit protection circuitry works as follows:

1. The supply current is sensed by R23. When the output current of U5 reaches approximately 50 mA, the voltage across R23 is large enough to turn on Q10.
2. As Q10 turns on, the voltage across R20 increases, and pulls down the supply voltage at pin 4 of U5.
3. In order to prevent the supply of U5 from dropping below the input, Q8 saturates turning on Q11 which shorts the input to FR1 COM.
4. When the short is removed, R22 and C41 cause Q11 to turn off slowly, which prevents a large overshoot at the DAC output.

Sense Current Cancellation Circuit *2-107.*

This circuit uses op amp U1A and four resistors on the HR6 assembly. This circuit supplies the sense current of equal, but opposite, polarity to the feedback resistors in the 22V range. This eliminates current in the sense lead during external sensing.

Linearity Control Circuit *2-108.*

The linearity control circuitry contains the series linearity control circuit and the shunt linearity control circuit, as outlined on the schematic. These linearity control circuits eliminate filter current in the series switch (Q5) and the shunt switch (Q6). This is necessary because Q5 and Q6 have finite resistance (3 to 5Ω) and a small mismatch in the resistances can cause a linearity error.

The series linearity control circuit uses op amp U38, resistor network Z2, and a single 19.996 kΩ resistor on the HR5 assembly. This circuit eliminates filter current in the series switch Q5.

When the series switch (FET Q5) is on, it connects the 13V reference to the first channel input of the filter, and FET Q4 is also turned on. This causes U38 to supply the current to the filter through the 19.996 kΩ resistor in HR5 and Q4, which makes the resistance from TP2 to TP5 look like near 0 ohms.

The shunt linearity control circuit uses op amp U2B, FET Q22, three 80 kΩ resistors on the HR6 assembly, and one resistor in the HR5 assembly.

Op amp U2B is configured as an amplifier with an inverting gain of 1 in the 11V range, and an inverting gain of 0.5 in the 22V range. This gain is determined by FET Q22 and the three 80 kΩ resistors in the HR6 assembly.

When the shunt switch (FET Q6) is on, connecting the input of the filter to REFCOM, the current from the filter flows through the two 40 kΩ resistor (pin 7 to pin 8) on the HR6 assembly to the output of U2B. This cancels out the current that would flow through Q6 which makes it look like 0Ω.

Negative Offset Circuit 2-109.

This circuit creates a constant offset voltage of approximately -127 mV at the filter input. Thus, for a DAC output voltage of 0V, the first channel count must be approximately 400 to offset this negative voltage. This guarantees a minimum duty cycle pulse width of approximately 50 us.

This minimum duty cycle is necessary to overcome the offset of the output stage and to allow the reference voltage to settle out after being switched into the filter input. Op amp U2A and two 20 kΩ resistors in HR6 form an amplifier with an inverting gain of 1. This amplifier input is the 13V reference which produces -13V at its output. This -13V is divided by resistors in the HR5 assembly to create the -127 mV on the filter input.

DAC Output Switching 2-110.

The floating outputs of the DAC are switched with latching-type relays K1, K2, K3, K4, and K8.

Relays K1 and K2 determine the polarity of the DAC. In the reset position, the DAC output is positive. In the set position, output is negative. Relay K1 also generates DAC LO DIAG and DAC HI DIAG which are used by the adc circuit during DAC diagnostics.

Relays K3 and K4 switch the DAC to various assemblies. In the reset position, the DAC is available to all assemblies except the oscillator. Relays K3 and K4 are set during operation in the ac function so the DAC output is connected to the DAC/OSC lines which run only to the Oscillator assembly. Also during operation in the ac function, control line DAC OUT SEL turns on FET Q25, via FET Q26, to connect SCOM to RCOM.

Relay K8, when in the set position, allows the DAC to be sensed right on the output of the DAC assembly.

DAC Buffered Reference Sip 2-111.

The DAC Buffered Reference SIP assembly (A11A2) has two main functions. First, it buffers the 6.5V and 13V references so they can be used by other assemblies.

The 6.5V reference, REF6, is buffered by op amps U1A and U2A which creates BRF6 and its sense line BSRF6. The 13V reference, REF13 FILT, is buffered by op amps U1B and U2B which creates BRF13 and its sense line BSRF13. These are routed to other assemblies in the calibrator for use during calibrator calibration.

Second, it allows the reference voltages, or the buffered reference voltages, to be switched to the REFCAL line, which is connected to the inverting input of the adc amplifier by K5 during calibration of the DAC assembly.

Control line REF6 SEL and FETs Q1 and Q2 connect the 6.5V reference REF6 to REFCAL.

Control line BSRF6 SEL and FETs Q5-Q7 tie BRF6 and BSRF6 together and connect them to REFCAL.

Control line REF13 SEL and FETs Q8 and Q9 connect the 13V reference REF13 to REFCAL.

Control line BSRF13 SEL and FETs Q12-Q14 tie BRF13 and BSRF13 together and connect them to REFCAL.

ADC COM can also be connected to REFCAL by FET Q15 and control line ADC COM SEL.

Self-Calibration Hardware *2-112.*

The main components of the calibration hardware are the adc amplifier and the adc (analog to digital converter). This adc circuitry converts dc analog voltages into 22-bit binary numbers which the software interprets.

ADC Amplifier *2-113.*

ADC amplifier circuitry is located on sheet 4 of the DAC schematic. The adc amplifier is used like a null detector. It has two inputs (inverting and noninverting) and a single output with ADC AMP OUT and ADC AMP SENSE connected together.

The noninverting input (+INPUT) is switched between ADC COM, RCL, or DAC SENSE CAL by relays K6 and K7. DAC SENSE CAL is the output of the DAC and RCL is the calibration line which other assemblies use during their calibration.

The inverting input (-INPUT) is switched between DAC SENSE CAL and REFCAL by relay K5. ADC amplifier inputs are high impedance. The output voltage is the voltage difference between the inputs multiplied by the overall adc amplifier gain of 11.

To determine adc amplifier output, the following formula is used: (Noninverting input - inverting input) x 11 = adc amplifier output. For example, if the noninverting input is a 5.0V and the inverting input is at 5.1V, the output would be -1.1V. (The calculation for this example is (5.0V - 5.1V) x 11 = -1.1V.) Op amp U20A configured as an amplifier with an inverting gain of 1 is used to cancel the current in ADC COM generated from op amp U19A.

Zener diodes VR19 and VR20 keep the output of the adc amplifier from exceeding ±4.0V. Similarly, this protection is provided for the adc amplifier inputs by VR17, VR18, VR21 and VR22.

ADC Input Selection *2-114.*

The input to the adc chip, U25, is selected by a quad FET analog switch array, U23. A large filter (R74 and C84) and a buffer (U24) are put on the adc input line to filter out 60 Hz and 190 Hz before it is connected to the adc chip input (pin 22).

During calibrator diagnostics, control line PC2 selects the SDL (system diagnostic line) line, which is used by other analog assemblies to monitor their diagnostic voltages.

During diagnostics of the DAC assembly control, line PC3 selects DAC HI DIAG which is divided by R79 and R84. Control line PC4 selects DCAMP HEATER and REF HEATER which are summed and divided by R80, R81, and R83.

Since DCAMP HEATER and REF HEATER are referenced to FR1 COM, DAC LO DIAG is buffered by U22 to provide the proper current return.

During calibrator calibration, control line ADC OUT SEL selects the output of the adc amplifier.

ADC Circuit 2-115.

The adc (analog-to-digital converter) is shown on sheet 5 of the DAC schematic.

Most of the adc is contained on one chip (U25) which uses the Fluke-patented recirculating remainder technique.

The adc has rms noise of approximately 20 μV between readings. This is reduced by a factor of 5 by averaging the readings. The adc measures input voltages between -1.8V and +1.8V.

Hardware for the adc has four major sections external to adc IC U25. These sections are:

- ADC reference voltage
- ADC dac
- ADC comparator/amplifier
- Timing/data control circuitry.

The adc reference voltage circuit is made up of zener diodes VR29, VR30, and resistors R91-R93, which generate a 6.4V reference. This -6.4V is inverted by U27B to create the +6.4V reference and is also buffered by U27A and connected to U25. A reference common point for the adc reference is made by buffering ADC COM with op amps U20B and U26A, resulting in an isolated ADC COM. Buffering allows the common point to be referenced to ADC COM, yet current from R85, C89, C90, R93, VR29, and VR30 to return to SCOM through the output of the buffer instead of through ADC COM.

The adc dac contains the dac amplifier, U28B, and a binary ladder network consisting of resistors in Z10. Digitally controlled analog bit switches are contained in U25. The bit switches determine the output voltage of U28B by control of the binary ladder network. The output voltage of U28B can be varied from -1.95V to 1.95V.

The adc comparator/amplifier contains op amp U29, two remainder storage capacitors (C89 and C90), an autozero storage capacitor (C95), and several digitally-controlled analog switches in U25.

The supplies for U29 are bootstrapped off its input voltage. This circuitry includes U28A, VR31-VR34, R95-R100, Q56, Q57, and C97.

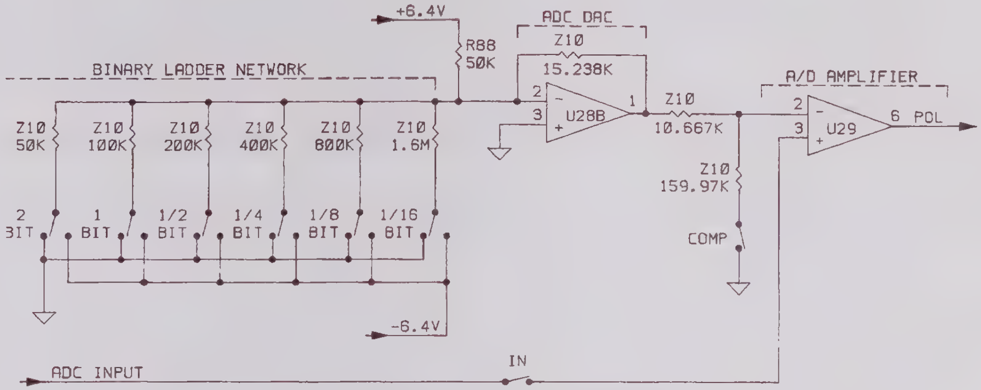
The timing/data control circuit is the digital portion of U25. This internal circuitry controls the adc by manipulating the switches in the adc comparator/amplifier and the bit switches in the adc dac.

An adc conversion cycle is triggered by the falling edge of control line ADC TRIGGER from the digital control circuit. Once triggered, the adc, under control by U25, generates five 6-bit nibbles without any further interaction.

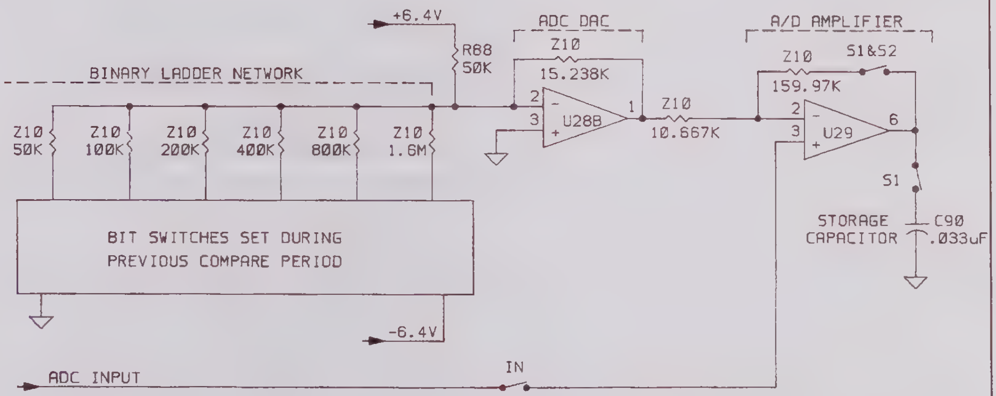
Once the adc is triggered, it goes through five measurement cycles. Each cycle is made up of three functions, an autozero function, a compare function and a remainder store function. Figure 2-18 illustrates these three functions.

Before the adc is triggered, it stays in the autozero function. In this function, the adc dac is set to 0V with some offset error. Through U25, pin 3 of U29 is connected to ADC COM and pins 2 and 6 are connected together. In this function, the offset of the adc dac is stored on C95.

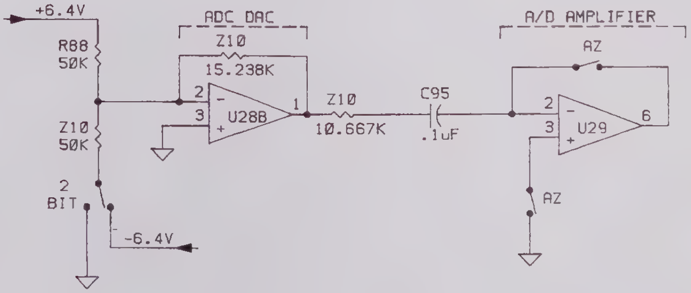
In the compare function, U29 compares the adc dac with the adc input (during the first pass) or the stored remainder (C89 or C90) during the remaining four passes. The voltage to be measured is switched into pin 3. The adc dac is connected to pin 2 and adjusted according to the polarity output of U29 resolving the voltage on pin 3. During this function the six bits of one nibble are determined.



ADC DURING FIRST COMPARE PERIOD



ADC FIRST REMAINDER STORE PERIOD



ADC AUTOZERO PERIOD

Figure 2-18. ADC Circuit Measurement Functions

During the remainder store function, U29 amplifies and stores the difference between the ADC INPUT and the adc dac output on one of the remainder storage capacitors, C89 or C90. In this function, U29 is configured by the adc as a difference amplifier with a gain of 16. The output of U29 is now the difference between the input voltage and the DAC voltage, multiplied by 16. This voltage is stored on C89 or C90.

On the next cycle, this remainder voltage is switched into U29 as the input voltage during the compare function.

Once this is repeated five times, U25 sends out an interrupt signal (ADC INT) to tell the processor that it is waiting to read. To read the five passes of the adc, the processor reads port A of the 82C55 five times.

For the most critical applications, the adc measures the output of the adc amplifier. Since the output of the adc amplifier is adjusted until it reaches a checkpoint voltage, the adc needs only to be repeatable at this voltage and low in noise. This reduces the constraints on adc linearity and long term stability which allows a much simpler adc reference to be used.

How the DAC is Used in Self-calibration *2-116.*

For internal and external calibration, the adc amplifier output is switched to ADC INPUT.

The adc amplifier acts as a null meter. It measures the voltage difference between its inverting and noninverting inputs and amplifies it by a gain of 11.

The adc amplifier can measure common-mode voltages up to 14V. Input switching circuitry allows the DAC SENSE, buffered and unbuffered reference, RCL, and ADC COM to be switched into the adc amplifier inputs.

To make a typical cal measurement, software sets the DAC to the approximate expected common-mode voltage. The DAC is then switched into both adc amplifier inputs and an adc reading is taken. This is the checkpoint measurement. It represents the adc amplifier common-mode and offset error, and the errors in the adc and adc amplifier input switching. The unknown voltage is switched into one input of the adc amplifier and the DAC is adjusted by software until the adc reading matches the checkpoint reading. At this point the unknown voltage is equal to the DAC voltage and is represented by the current DAC counts.

DAC Assembly Calibration *2-117.*

The DAC assembly is completely characterized using a single external 10V source. Calibration occurs in the following steps:

Ratio calibration of the first and second channels is performed first. The first channel count is set for a DAC output of near 0V. The second channel count is set to its minimum value of approximately 10,000. The DAC output is connected to the input of the zero amplifier on the Switch Matrix assembly (A8) and its output connected to the +input of the adc amplifier via the RCL line and the -input is connected to ADC COM.

The adc measures this value and stores it as a checkpoint reading. The first channel is decremented by one count and the second channel is increased until the adc reads the same as the previous checkpoint. The number of counts the second channel is increased represents the channel ratio constant.

The ±11V and ±22V range zeros are calibrated next. This is done by the same technique as the ratio cal except the checkpoint reading is obtained by connecting the input of the zero amplifier on the Switch Matrix assembly to RCOM. The DAC output (DAC SENSE

CAL) is then connected to the zero amplifier input and adjusted until the adc reads the same as the previous checkpoint. This determines the exact first and second channel counts for a 0V output.

Next, the +11V and +22V range gain constants are calibrated by nulling the DAC to the external 10V source, connected to the front panel binding posts of the calibrator. This 10V source is connected to the RCL line by relays on the Switch Matrix assembly (A8).

The RCL line is connected to the +INPUT of the adc amplifier. The DAC output is connected to the -INPUT of the adc amplifier and is adjusted until the adc reads a null. This determines the first and second channel counts required for an exact 10 V output from the DAC. Software determines floating point gain constants from these counts.

The exact value of all the reference voltages (6.5V and 13V) are determined next. The reference voltage to be determined is connected to the -INPUT of the adc amplifier. The DAC output is connected to the +INPUT and adjusted until the adc reads a null. The reference voltage is the value to which the DAC is set. This procedure is done for the 6.5V buffered and unbuffered, and 13V buffered and unbuffered references.

Oscillator Section Overview 2-118.

The ac module consists of two plug-in assemblies, the Oscillator Output assembly (A13) and the Oscillator Control assembly (A12). These assemblies generate a precision amplitude-stabilized ac sine wave from 0.22V to 22V with a frequency range of 10 Hz to 1.2 MHz. This signal is either routed to the OUTPUT binding posts if the desired output is within this range, or used internally by the Power Amplifier, High Voltage, Wideband, Current, Switch Matrix, or an Auxiliary Amplifier (Model 5725A, 5205A, 5215A, or 5220A) for voltages and/or functions outside this range.

Output sensing of the amplitude helps obtain an accurate output signal regardless of output amplitude and load variations. Sensing is available for all voltage ranges above 200 mV at the calibrator SENSE binding posts. In the current function, and for voltages less than 200 mV, sensing is performed internally and output accuracy is guaranteed only for specified operating conditions.

The Oscillator Output assembly (A13) creates an ac voltage. The Oscillator Control assembly (A12) controls the amplitude of this ac signal by comparing the SENSE HI signal from the Oscillator Output with an accurate dc voltage from the DAC assembly (A11). The Oscillator Control assembly adjusts the amplitude of the Oscillator Output via the OSC CONT line. The frequency accuracy is controlled by the phase-locked loop circuit on the Oscillator Output assembly, which phase locks to the signal created by the Current/Hi-Res assembly (A7), or to an external signal connected to the Calibrator rear panel through the PHASE LOCK IN jack.

The following discussions separately cover these two assemblies.

Oscillator Control Assembly (A12) 2-119.

The Oscillator Control assembly (A12) contains all the precision ac amplitude control circuitry except the output AGC amplifier, which is located on the Oscillator Output assembly (A13). The primary function of the Oscillator Control assembly is to monitor the output of the Calibrator in the ac voltage function, and to adjust the output until the rms voltage across the SENSE point is equal to the voltage requested by the operator. This assembly provides amplitude control for both the ac current function and the Wideband AC Module (Option -03) during low-frequency operation.

The oscillator control circuitry contains an averaging converter, an error intergrator, a three-pole filter, an ac/dc thermal transfer circuit, an ac/ac thermal transfer circuit, a 15-bit dac, and a digital control circuit.

All power supplies used by this assembly are generated by the Guard Crossing/Regulator assembly (A17) except the +5 OSC supply, which is generated by a three-terminal +5V regulator (U25) from the +15 OSC supply. The ±15 OSC supplies are buffered by L3, L4, C34 and C35 to create the ±15A supplies, and L1, L2, C86 and C87 to create the ±15B supplies. A +2.5V reference voltage is created from the +5LH supply by resistors R52 and R53. A -200 mV reference voltage is created from the -15V OSC supply by resistors R57 and R58 for use exclusively by the protection circuitry for thermal sensors U14 and U16.

Oscillator Control Digital Control 2-120.

The digital control circuit contains an 82C55 Programmable Peripheral Interface (U20) and latching relay drivers (U23, U24). The 82C55 is controlled via the guarded digital bus, and has three ports that generate 24 outputs. Port A (PA0-PA7) is a common input bus (DATA) for the relay drivers (U23, U24) and the 14-bit DAC (U10). Relay driver U23, which controls latching relays K1 through K4, K6, and K8, is strobed by PC5 and enabled by PC7 of port C. Relay driver U24, which controls latching relays K5, K7, and K9, is strobed by PC6 and enabled by PC7 of port C. The SW control bus contains control lines SW1-SW4 from PB4-PB7 of port B which control a CMOS analog switch IC U19. PC1-PC4 of port C create control lines GCAL, AC*/DC, DAC* and BIT14* respectively. The Oscillator Output assembly (A13) generates two more control lines: LFCOMP* and HFCOMP*. These control lines are routed to this assembly via the motherboard and enter on pins 18A/C and 19A/C of connector P502.

A self-diagnostic circuit contains a multiplexer (U18) and resistor networks Z5 and Z6. It monitors ±15V, VREF, and the outputs of the error integrator and 14-bit DAC. These inputs are divided by the resistor networks, while U18 applies one to the SDL line. The SDL line is routed to the DAC assembly (A11) to be measured by the adc circuit.

Oscillator Input Switching 2-121.

Relay K1 selects an input to the Oscillator Control assembly. During ac voltage operation, relay K1 is reset. This connects the input (SENSE HI) to the averaging converter and the ac sense buffer to OSC SENSE HI. The reference voltage, VREF, is connected to both DAC/OSC OUT HI and DAC/OSC SENSE HI, which is the dc voltage from the DAC assembly (A11). During internal calibration K1 is set, so VREF is the 6.5V reference voltage (BRF6 and BSRF6) from the DAC assembly. The input to the averaging converter and ac sense buffer is DAC/OSC OUT HI and DAC/OSC SENSE HI from the DAC assembly.

Sense Current Cancellation 2-122.

The SENSE HI current cancellation circuit, containing op amp U1, Q1, Q2, K8, K2B and associated components, supplies the current into SENSE HI (Z2 pin 1) so that no current is pulled from the OSC SENSE HI line. During operation in the 2.2V and 22V, range K8 is set so the input is OSC OUT. In the 220V range K8 is reset so OSC SENSE HI is connected to the input. Relay K2B is reset in the 2.2V range and set in the 22V range. Transistors Q1 and Q2 form a bootstrapped supply for U1.

The SENSE LO current cancellation circuit, built around op amp U2, forces the return current back to SCOM instead of OSC SENSE LO. Relay K2A is reset in the 2.2V range and set in the 22V range.

To better understand the detailed circuit descriptions for the averaging converter, error intergrator, and three-pole filter, refer to Figure 2-19.

Averaging Converter 2-123.

The averaging converter contains the buffer amplifier and rectifying amplifier circuits as outlined on sheet 1 of the schematic.

The buffer amplifier is a non-inverting unity gain amplifier (U3). Input to the buffer amplifier is either a 0 or 20 dB attenuator contained in Z2 as selected by K3. In the 2.2V range, SENSE HI is connected directly to the buffer amplifier with K3 in the reset position. In the 22V range, K3 is in the set position, so the buffer amplifier input (SENSE HI) is attenuated 20 dB by the 18 kΩ and 2 kΩ resistors in Z2. The buffer amplifier output voltage is always between 0.22 and 2.2V, and is capacitively coupled to the rectifying amplifier by C22 and C25.

The rectifying amplifier is comprised of U5, U7, Q3 and Q4, and has an inverting gain of 2. When the input voltage (from the buffer amp) is positive, feedback is negative through CR5 and a 2 kΩ resistor in Z1 (pins 6 and 5). When the input voltage is negative, the feedback path is through CR4 and a different 2 kΩ resistor in Z1 (pins 3 and 5). This amplifier produces a full-wave rectified negative output current proportional to input voltage. Output current is summed at the input of the error intergrator with the positive adjustable reference current (VREF, which is the output of the DAC assembly).

Error Integrator 2-124.

The error integrator circuit contains op amp U11, CMOS analog switch U8A, and capacitors C42 and C43. When operating at frequencies above 119 Hz, op amp U11 and C43 form an integrator. When operating at frequencies below 119 Hz, control line LFCOMP* goes low to close U8A, adding C42 to C43. This reduces the integrator crossover point by a factor of ten. If the magnitude of the averaging converter dc output current is different than the reference current, the output of the error integrator begins to change. Error integrator output goes through a three-pole filter and is buffered by U9A to generate OSC CONT. OSC CONT is routed to the Oscillator Output assembly to adjust the Oscillator amplitude. The output of the error integrator is also monitored by the diagnostic circuit via ERROR INT. OUT.

Three-Pole Filter 2-125.

The three-pole filter contains op amp U9B, CMOS analog switches U8B-U8D, and C26-C31. This circuit filters out ac from the output of the error integrator. Control line LFCOMP* goes low when operating at 119 Hz or less to reduce the crossover point.

Analog Amplitude Control Loop 2-126.

This loop is comprised of the averaging converter, error integrator, three-pole filter, and the agc amplifier on the Oscillator Output assembly (A13). It stabilizes the Calibrator output voltage in the presence of load changes. This loop by itself is very stable but does not have the conversion accuracy or gain flatness necessary to meet the precise amplitude specifications of the Calibrator. Thus this circuit is used only to provide quick load regulation recovery and short term output stability.

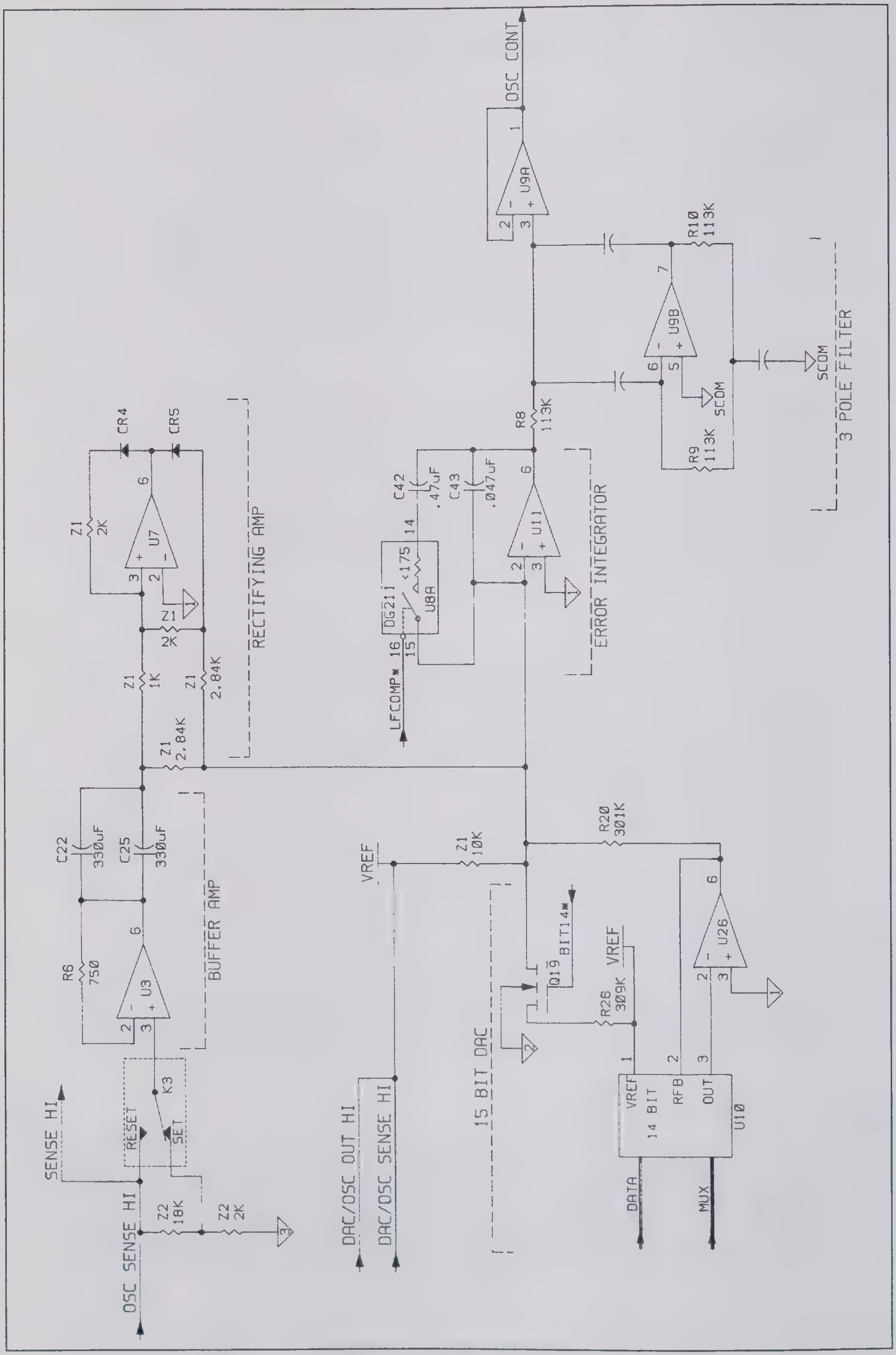


Figure 2-19. Oscillator Control Analog Control Loop

AC/DC Thermal Transfer Circuit *2-127.*

Refer to Figure 2-20 for the following discussion. The ac/dc thermal transfer circuit achieves basic mid-band amplitude accuracy. This is done by first applying the reference voltage (VREF) to the thermal rms sensor (U14) and measuring the output. Next, the ac voltage is applied to the thermal rms sensor and the dc output is compared to the previous reading. The sensor detects the difference between the ac and dc input voltages to within a few ppm.

If there is an ac/dc difference, the dc reference current applied to the error integrator of the analog control loop is adjusted via the 15-bit dac until the ac/dc difference is zero. The ac/dc thermal transfer circuit that performs this function is further described in detail. It contains the dc sense buffer, ac sense buffer, ac/dc thermal sensor, and the square-root amplifier and 15-bit dac as outlined on the schematic.

As previously mentioned, the input to the thermal rms sensor is either the dc reference voltage (VREF) buffered by the dc sense buffer or the ac voltage (SENSE HI) buffered by the ac sense buffer.

The dc sense buffer circuit uses op amp U30 as a buffer amplifier. Enhanced-mode FET Q10 provides feedback for U30 while FETs Q8 and Q9 are off. During a dc transfer, control line AC*/DC and comparator U21C turn on the FETs, applying the output of the dc sense buffer to the input of thermal rms sensor U14.

The ac sense buffer circuit contains op amps U12A, U12B, U13; FETs Q6, Q7, Q11, Q12; relay K4, and associated components. Relay K4 selects the input resistance to amplifier U13, which has a nominal inverting gain of 0.316 in the 22V range and 3.16 in the 2.2V range.

During operation in the 22V range, relay K4 is set, feeding the input, SENSE HI, through the 20 kΩ resistor in Z3. When operating in the 2.2V range, the 2.22 kΩ and 20.0 kΩ resistors in Z3 are put in parallel by K4 in the reset position, reducing the input resistance to 2 kΩ.

During an ac transfer, control line AC*/DC and comparator U21D turn on FET Q12 so the output of amplifier U13 is applied to the input of thermal rms sensor U14. At this time, FET Q11 is turned off and the feedback path for U13 is through the 6.32 kΩ resistor in Z3.

During a dc transfer, Q12 is off and comparator U21B turns on FET Q11, providing the feedback path for U13. Op amps U12A and U12B provide low offset and increase the gain. Control line HFCOMP and comparator U22C turn on FETs Q6 and Q7 during operation in the 1 MHz range.

The output of either the dc sense buffer or the ac sense buffer becomes the input of thermal rms sensor U14. During operation from 0.22V to 0.7V in the 2.2V range, or 2.2V to 7V in the 22V range, relay K7 is set, directly connecting the input signal to the sensor. The input to the thermal sensor is through R31 by K7 in the reset position during operation from 0.7V to 2.2V in the 2.2V range, or 7V to 22V in the 22V range.

Comparator U21A provides protection for thermal rms sensor U14. If the junction temperature of the sensor goes above 200°C, the voltage at pin 3 increases, driving the output of U21A negative. This turns off the FETs controlling the output of the dc sense buffer. The ac sense buffer gain goes to zero by turning on FET Q11.

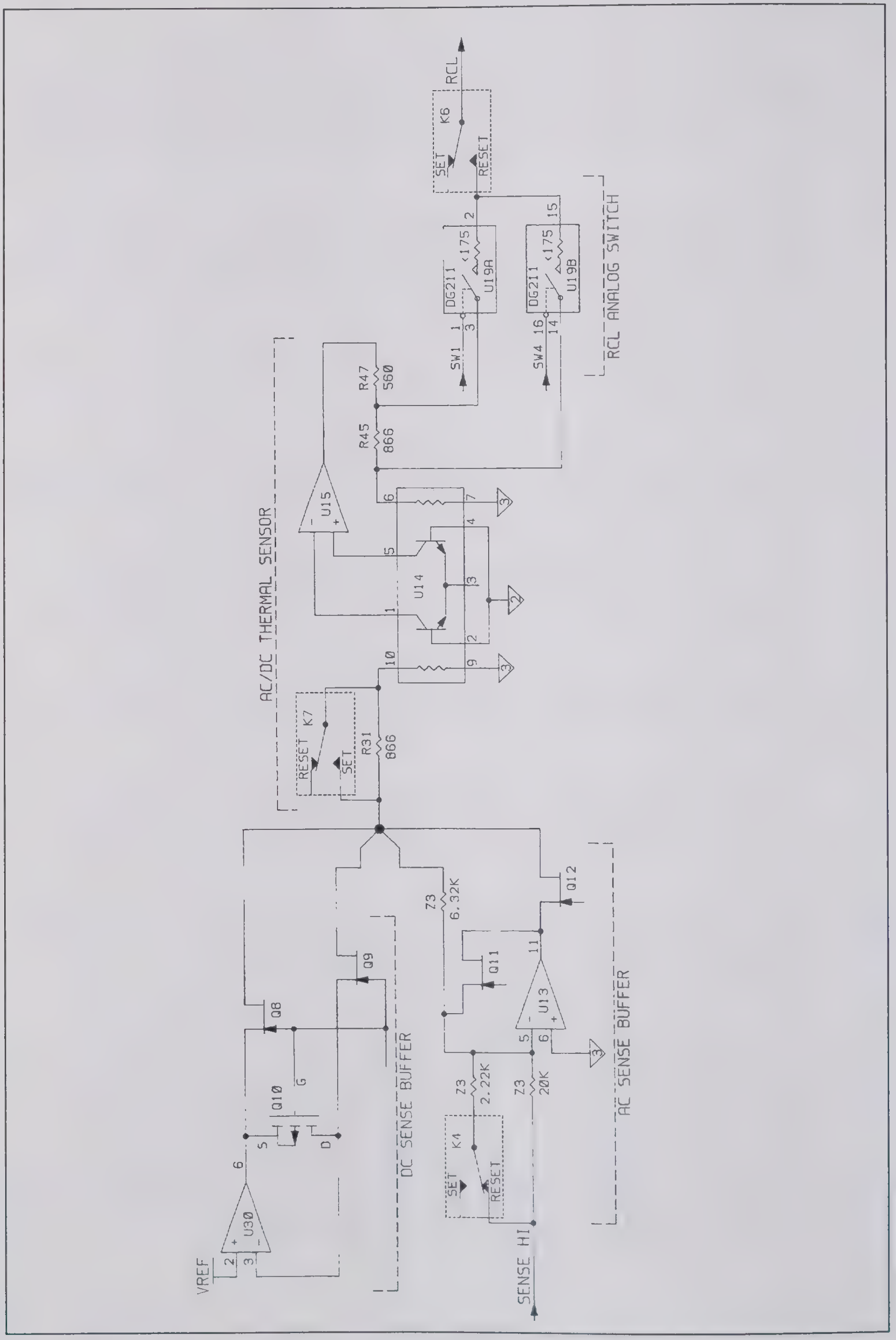


Figure 2-20. AC/DC Thermal Transfer Circuit

The ac/dc thermal sensor and square-root amplifier, as outlined on the schematic, contain the thermal sensor U14, op amp U15 and transistor array U17. The dc voltage from the thermal sensor is connected to U15B configured as an integrator. Comparator U22B is used to control FETs Q18 and Q20. These FETs are turned on, adding C84 and C62 to the integrator, by control lines LFCOMP* and AC*/DC both at logic low. The output of integrator U15B is used by the square-root amplifier contained in U15A, U15C and U17. This circuit keeps the settling time of the sensor constant when its input is varied between full and 1/3 scale. The output of the sensor is connected to the RCL line by relay K6 and CMOS analog switch U19A and U19B. During operation from 0.22V to 0.7V in the 2.2V range, or 2.2V to 7V in the 22V range, sensor output is connected to the RCL line through buffer U31, U19B, and K6 in the set position. During operation from 0.7V to 2.2V in the 2.2V range, or 7V to 22V in the 22V range, sensor output is connected to the RCL line through U19A and K6. Control lines SW1 and SW4 control U19A and U19B respectively. The RCL line is routed to the DAC assembly (A11) where its amplitude is measured by the adc circuit.

To do an ac/dc transfer, the dc sense buffer is connected to the thermal sensor and the sensor output is connected to the +input of the DAC's adc circuit. The -input of the adc circuit is connected to the DAC output (VREF), and the difference between the two is measured and stored in memory. Next, the output of the ac sense buffer is connected to the sensor and the sensor output is connected to the +input of the DAC's adc circuit. The difference is measured and compared to the previous reading. The difference between these two readings is the difference in rms value of the ac and dc input voltages. If there is an ac/dc difference, the dc reference current applied to the error integrator of the analog control loop is adjusted via the 15-bit dac until the ac/dc difference is zero.

The 15-bit dac contains an AD7534 dac IC (U10), FET Q19 and op amp U26. The first 14 bits (bits 0-13) are generated by the dac IC U10, and bit 14 is generated by Q19, R26, and control line BIT14. Control busses DATA and MUX from the digital control circuit select the data and address for U10. The output is inverted by U26 to create 14 BIT DAC OUT, which is applied to the summing node of the error integrator by R20. This output is also monitored by the diagnostic circuit.

Oscillator Calibration *2-128.*

Calibration consists of determining the offset and gain errors of the ac/dc switching circuitry. Errors are measured at dc using the calibrator DAC and the 6.5V reference as the primary sources of accuracy. This characterization is valid for frequencies up to 1 kHz. Above 1 kHz, ac/ac characterization is used to ensure the output accuracy.

The DAC assembly (A11) is set to 0V with its output connected to the ac sense buffer (via SENSE HI) by relay K1 in the set position. The output of the ac sense buffer is connected to the RCL line by K6 in the set position and by control line GCAL and comparator U22A turning on Q13. The 0V input is stored as Vin1. The output measured by the adc circuit on the DAC assembly is stored as Vout1.

Relay K1 ties 6.5V reference BRF6 and BSRF6 to VREF, where it is measured at the output of the thermal sensor in the same manner as a dc transfer. This measured output is stored in memory.

The DAC output is set to 20V or 2V and is measured at the output of the thermal sensor in the same manner as an ac transfer. The DAC is then adjusted until this measured output is the same as stored in the previous step. The DAC setting is stored as Vin2 and the 6.5V reference is Vout2. The gain can now be calculated with the formula: (Vout2 - Vout1)/(Vin2 - Vin1).

AC/DC Frequency Response Characterization 2-129.

Characterization is accomplished by first performing an ac/dc transfer with the Oscillator Output set to a low frequency. The ac/ac thermal sensor circuit, containing the thermal sensor U16 and op amp U15D, characterizes the frequency response of the main ac/dc thermal sensor. This sensor has no active circuitry at its input, and all switching is done by relays to ensure a flat frequency response.

In the 20V range, the Oscillator Output is switched through R34 to the ac/ac thermal sensor via SENSE HI, K5, and K9 in the set position. In the 2.2V range, R34 is bypassed by K9 in the reset position. The output of this sensor is routed to the RCL line via U19C and K6. A reading is taken and stored in memory as ACref.

The output frequency of the Oscillator Output is changed to the first cal point and the 15-bit dac is adjusted until the reading from this ac/ac thermal sensor is the same as ACref.

The RCL line is then switched back to the ac/dc thermal sensor. A reading is taken stored in memory as ACdif. The gain constant is calculated using the formula (ACdif + Vdac)/Vdac, where Vdac is the DAC assembly (A11) voltage.

This ac/ac transfer function is also performed for the 220V range and the 1100V range. These ranges are generated by the Power Amplifier assembly (A16) and the High Voltage/High Current assemblies (A14 and A15). High voltage ac signals are attenuated and connected to AC CAL, where they are connected to the sensor though relay K5 in the reset position. In the 220V range, the output of the sensor is divided by Z4 and connected to the RCL line by U19D and K6.

Protection for this thermal sensor is provided by comparator U22D, FET Q14, zener diodes VR5, VR6, resistor network Z10, and diodes CR12 and CR13. During normal operation, U22D keeps Q14 off. If the junction temperature of the sensor goes above 200°C, the voltage at pin 3 increases, driving the output of U22D positive. This turns on Q14, shunting the input of the sensor to common through CR12 and CR13.

Oscillator Output Assembly (A13) **2-130.**

The Oscillator Output assembly is controlled by the Oscillator Control assembly. Refer to Figure 2-21 and the schematic diagram for the following discussion.

The Oscillator Output assembly generates an ac sine wave from 0.22V to 22V with a frequency range of 10 Hz to 1.1999 MHz. There are five frequency ranges (100 Hz, 1 kHz, 10 kHz, 100 kHz and 1 MHz) and two voltage ranges (2.2V and 22V). The output signal is either routed to the OUTPUT binding posts, or it is used internally by the Power Amplifier, High Voltage, Wideband AC Module (Option -03), Current, or Switch Matrix assemblies, or it is routed to an Auxiliary Amplifier for generation of voltages and/or functions outside this range. Output sensing is available for all voltage ranges above 220 mV at the SENSE binding posts.

The Oscillator Output assembly contains a fixed-amplitude quadrature RC oscillator, a 0.22-22V digital/linear gain-controlled amplifier, a fixed-amplitude variable phase-shifting network, phase-locked loop control circuitry for phase locking to an external signal or the PLOCK signal from the Current/Hi-Res assembly (A7), and digital control circuitry.

All power supplies used by this assembly except the -12S supply are generated by the Guard Crossing/Regulator assembly (A17). The -12S supply is generated on this assembly by a three-terminal -12V regulator (U2) using the -17S supply as its input.

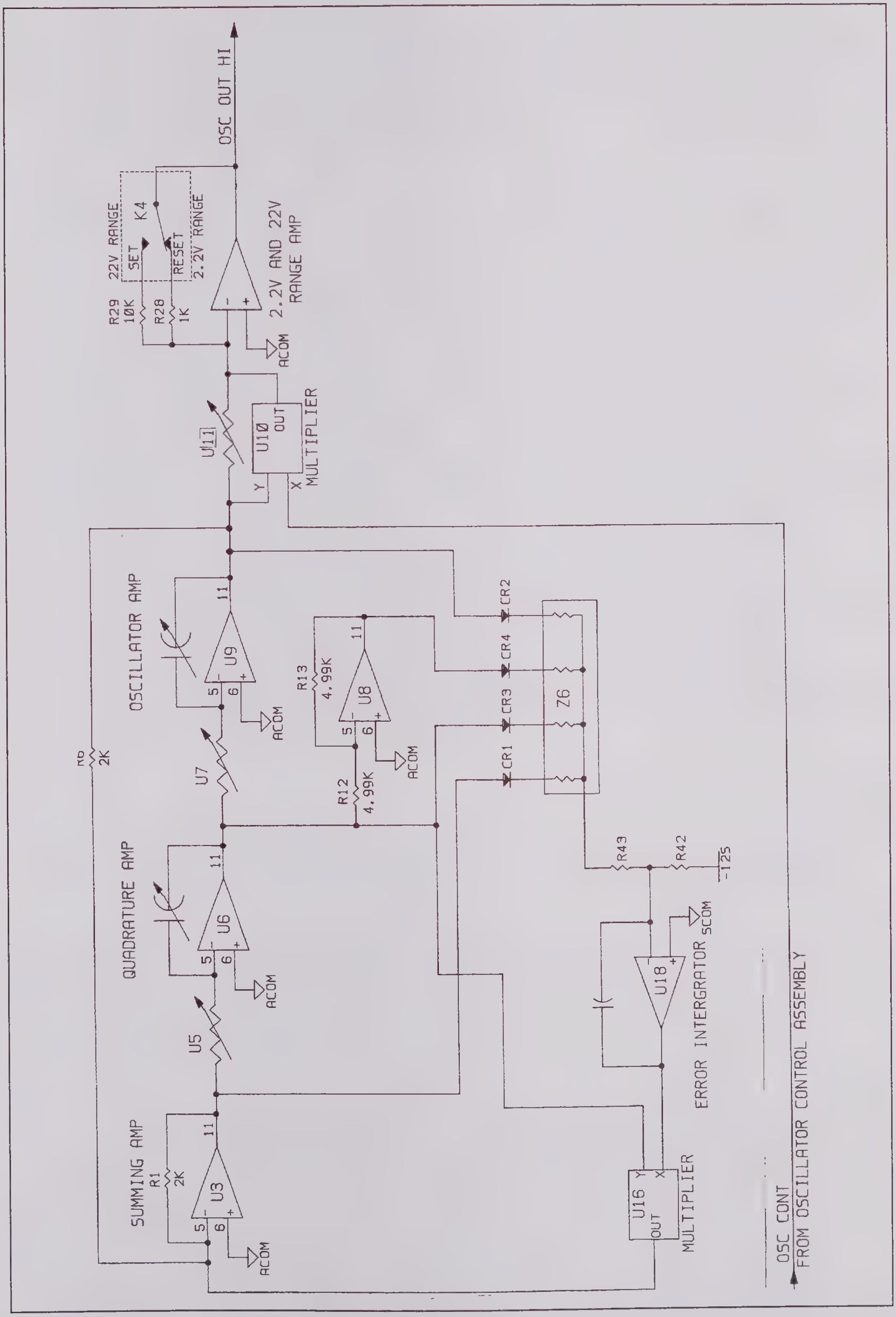


Figure 2-21. Quadrature RC Oscillator Circuit

Oscillator Output Digital Control 2-131.

The digital control circuit consists of an 82C55 Programmable Peripheral Interface (U26), a 5801 Latching Relay Driver (U24), and three HC374 Octal D-Type Flip Flops (U12, U32, U33). The Programmable Peripheral Interface (U26) is under software control via the guarded digital bus and has three ports which generate 24 outputs. Port A (PA0-PA7) is a common input bus for U24, U12, U32, U33, and U28. Latching relay driver U24 controls the four latching relays K1-K4. Relays K1-K3 select the frequency range and K4 selects the voltage range. This IC is strobed by PC3 of port C and enabled by PC6 of port C. To ensure that the relays are latched properly the driver must be enabled for 10 ms.

Latch U32 is clocked by PC0 and generates the data bus FREQ DATA for controlling 8-bit resolution hybrid resistive dacs U5 and U7. Latch U12 is clocked by PC1 and generates the data bus AMPL DATA for controlling U11, which is identical to U5 and U7. Latch U33 is clocked by PC2 and generates control bus PHASE, which controls multiplexer U27 in the phase shifter circuit and control bus MUX, which controls the SDL multiplexer U25 in the diagnostic circuit. This diagnostic circuit monitors the ±44S supplies, ±15S supplies, INTEGRATOR OUT, LOOP FILTER OUT, and AMP1 which is from U30, the A13A1 assembly. These voltages are divided by Z2 and Z3 and connected to the SDL line by multiplexer U25, where they are measured by the adc circuit on the DAC assembly (A11).

PB0-PB2 of port B generates control bus PLOCK RNG which is used in the phase-locked loop circuit. PB4 is control line 0/180 to control FET Q7 via comparator U31B in the phase-locked loop circuit. PB6 is control line LFCOMP* to control FET Q6 via comparator U20A in the integrator circuit. PB7 is control line HFCOMP*, which is routed to the Oscillator Control assembly (A12). PC4 and PC5 are control lines DAC STRB and DAC SEL respectively, which control the dual 8-bit dac U28 in the phase shifter circuit. PC7 is control line INH to enable the multiplexer U25 in the diagnostic circuit.

Quadrature RC Oscillator 2-132.

The quadrature oscillator is a double integrator type. It contains two op amp RC integrators and a unity-gain inverting summing amplifier. The integrators are identical and use relay-switched feedback capacitors to select five frequency ranges. An 8-bit resolution resistive dac selects frequency within a range.

The summing amplifier uses op amp U3 to provide a 180° phase shift in the oscillator loop at unity gain. Its exact phase shift and gain are adjusted by the amplitude control and phase-locked loop circuits to satisfy the conditions required for amplitude stable oscillation: exactly 360° loop-phase and unity gain. This amplitude control circuit uses an integrator and multiplier as outlined on sheet 1 of the schematic. These two circuits are described in detail later.

The two op amp RC integrators are the quadrature amplifier and the oscillator amplifier. Their purpose is to provide -90° each to the loop phase with an amplitude slope of -20dB/decade. The quadrature amplifier contains op amp U6, 8-bit resolution resistive dac U5, and relays K1B, K2B, and K3B. The relays select feedback capacitors C25, C24, C22, and C21 for frequency ranges 100 Hz, 1 kHz, 10 kHz and 100 kHz respectively. For the 1 MHz range, all the above capacitors are removed from the loop, and the only feedback path is C19. The input resistor is the 8-bit resolution resistive dac U5 which is under the control of the FREQ DATA bus from the digital control circuit. Its equivalent resistance is $R = (256/X)*2\ k\Omega$, where X is the digital code on the FREQ DATA bus. The oscillator amplifier contains op amp U9 and performs the same function as the quadrature amplifier. Its input resistance is controlled by resistive dac U7. Relays K1A, K2A, and K3A select the feedback capacitance. Since their phase shift is constant with frequency and the sum of the phase shifts around the loop is zero for all frequencies, we have satisfied one half of the requirement for oscillation. In summing the gain in dB around the loop it is apparent that unity gain occurs at only one frequency. This happens when the closed loop gains of the integrators are unity. This corresponds to F = 1/(2 x PI x R x C), which is the frequency of oscillation.

Oscillator Amplitude Control *2-133.*

Since small excess phase shifts exist in all three amplifiers and the gain of the summing amplifier cannot be made exactly one, it is impossible to generate an amplitude-stable sinusoidal waveform from just these elements. A control circuit consisting of an error integrator and a linear four-quadrant multiplier is used to sense the output amplitude and stabilize it by adjusting the loop phase shift slightly.

To do this, a fourth oscillator signal is generated using U8 to invert the output of the quadrature amplifier. The Oscillator now has four equal-amplitude signals all spaced 90° apart. These signals are rectified and summed by CR1-CR4 and Z6 in such a way that a dc representation of the output amplitude is created. This dc signal is summed with a -12V reference voltage by the error integrator circuit which contains op amp U18. If there is a magnitude difference between the rectified dc and the reference, the output of the error integrator changes. This in turn controls the amplitude of the oscillation. This is done via multiplier U16, a linear-variable resistance with a value inversely proportional to the error integrator output voltage.

If the control input (x input) to the multiplier is zero, the equivalent resistance from the signal input (y input) is infinite. If the control input is negative, the equivalent resistance is negative. The Y signal input of the multiplier is the quadrature amplifier output. Any nonzero control voltage changes the phase shift of the loop by injecting a small amount of out-of-phase current into the summing amplifier. This negative feedback is used to stabilize the amplitude of the oscillating signal by allowing one output amplitude only to satisfy the required conditions of oscillation. During operation in the 100 Hz range, control line LFCOMP* and comparator U20A turn off FET Q6.

Phase–locked Loop *2-134.*

The Oscillator Output assembly is phase locked to an external frequency to increase frequency accuracy. This external frequency comes from the High-Resolution Oscillator on the Current/Hi-Res assembly (A7) or from an external source connected to the rear-panel PHASE LOCK IN jack.

The frequency capture range is approximately ±5% of the nominal output frequency range. This is done by comparing the oscillator output frequency SUMMING AMP OUT or INT OSC OUT against the external frequency source P LOCK HI with a phase detector. The P LOCK HI signal is referenced to P LOCK LO. The phase-locked loop circuit locks SUMMING AMP OUT to the external frequency when the calibrator is in the 22V range or less. The phase-locked loop circuit locks INT OSC OUT, which is 180° out of phase from SUMMING AMP OUT, during calibrator operation at higher voltages. This occurs because the output from the Power Amplifier and High Voltage assemblies (which are used to generate the higher voltage ranges) are 180° out of phase from the Oscillator output. When the Calibrator is in the higher voltage ranges, control line 0/180 and op amp U31B turn on Q7, which selects INT OSC OUT to the Zero Crossing Detector.

Since the phase detector circuit requires digital inputs, both signals are converted to square waves using U23A/B as dual zero crossing detectors. Square waves from the zero crossing detector circuitry are fed to the phase detector circuit containing U22A/B and U21. The phase detector circuit looks for the falling edge of both signals. The first signal that makes a positive to negative transition causes the phase detector to turn on either the positive (CR5, CR6) or the negative (CR7, CR8) charge pump, depending on which signal is first. The Charge Pump is turned off when the other signal makes its transition. Thus the signal with the highest frequency has its respective charge pump pulsed on and off while the other charge pump remains off.

The accumulated charge is integrated by the loop filter circuit, which contains op amp U31A, multiplexer U17, Z1, and C75-C84. Multiplexer U17 is controlled by the PLOCK RNG control bus from the digital control circuit. This multiplexer changes the cross-over point of the loop filter by selecting C83 and C84 for feedback in the 100 Hz range. Capacitors C81 and C82 are used for the 1 kHz range, C79 and C80 for the 10 kHz range, C77 and C78 for the 100 kHz range, and C75 and C76 for the 1 MHz range.

The output of the loop filter controls two multipliers (U15 and U19) similarly to the amplitude control section. The only difference is that the signal input is derived from the in-phase signal. In the case of U15, the input signal is QUADRATURE AMP OUT, which changes the unity-gain frequency of the oscillator amplifier. In the case of U19, the input signal is SUMMING AMP OUT, which changes the unity-gain frequency of the quadrature amplifier. The new frequency of oscillation is the new unity gain frequency of the integrators. Under phase-locked conditions, neither charge pump is allowed to turn on because neither signal reaches the phase detector first.

2.2V and 22V Range Output Amplifier *2-135.*

The 2.2V and 22V range output amplifier is an inverting wide-band low-distortion amplifier that provides output signal OSC OUT HI at the OUTPUT binding posts in the 2.2V and 22V ranges. OSC OUT HI is used by the Power Amplifier and High Voltage assemblies to generate the higher voltage ranges.

This amplifier uses a surface-mount gain block (U30) called the Oscillator Wideband SMD PCA (A13A1) and a complementary Darlington emitter follower bootstrapped output stage. Relay K4 selects feedback resistor R28 for the 2.2V range and R29 for the 22V range. It also changes the open-loop frequency response for each voltage range. Its gain within a range is controlled by the gain control multiplier circuit and the dac gain control circuit.

The dac gain control circuit contains the same 8-bit resolution resistive dac (U11) as in the oscillator with the exception that it is controlled by the AMPL DATA control bus from the digital control circuit. This resistive DAC provides the coarse gain control. The gain control multiplier circuit contains a multiplier U10, which provides a small linear control range of several dac counts. The control input to the multiplier, OSC CONT, comes from the Oscillator Control assembly (A12). This allows the output amplitude to be adjusted as required by the Oscillator Control Assembly. The theory of operation for the rest of the output stage is described following the A13A1 theory.

Oscillator Wideband Smd Assembly (A13A1) *2-136.*

The A13A1 is a surface-mount assembly on the Oscillator Output assembly (A13) that provides the 22V output signals of the Calibrator. It is essentially an operational amplifier built using discrete components to provide the necessary speed, power output and breakdown voltage required for such a high output signal.

The input stage is a differential pair (Q2 and Q3) that is buffered by a source follower Q1. The transconductance is determined by R3, R4 and R26. The inherent input offset voltage of this stage is corrected by U1 and U2 and related components. The output of Q3 is level-shifted by VR5-VR7 before being applied to the mid stage. Transistor Q4 serves as a high-impedance current sink used to bias the input stage to approximately 10 mA. Potentiometer R30 adjusts the dc zero at the output of U2.

The mid stage is a common-emitter, Miller-compensated gain stage (Q5) that drives a common-base level shifter (Q13) on the Oscillator Output assembly. This stage is current limit protected by R12 and Q4. The dominant pole is set with the Miller capacitor C5 and the input stage transconductance. The mid stage is biased to 10 mA by Q6 and related components.

The output stage of the amplifier is a bootstrapped complementary Darlington pair. The only parts of the output stage on this A13A1 assembly are the input transistors Q7 and Q8. The output bias current is set by R17 and CR4-CR5 to be approximately 40 mA. This keeps the output stage class A for all normal output conditions.

Output Stage *2-137.*

The output stage circuit is a complementary Darlington emitter follower bootstrapped buffer amplifier. The input transistors are Q7 and Q8 on the A13A1 assembly. These transistors drive the output transistors Q8 and Q14 respectively. Transistors Q10 and Q11 in the positive side and Q16 and Q17 in the negative side are parallel transistors bootstrapped by VR3 and VR4. Current sources CR13, CR14, CR17, CR18, CR15, CR16, CR11, and CR20 provide the bias current for their respective bootstrapped transistors. Current limiting for the positive side is provided by Q9 and R91. During an overcurrent condition, the voltage drop across R91 turns on Q9, which draws current away from the base of Q11. Current limiting is done in the same manner for the negative side with Q15 and R99.

Switch S1 can be switched to pull the input of the A13A1 output stage low for troubleshooting the output stage. Refer to the Oscillator Output troubleshooting section for more information.

Phase Shifter *2-138.*

The phase shifter circuit provides a fixed amplitude variable phase auxiliary signal at the rear panel of the calibrator. This signal is the same frequency as the output, but can be phase shifted over a 360° range. The four phases (each 90° apart) for the oscillator circuit are divided by Z4 and Z5. These signals are connected to the dual four-channel multiplexer (U27), which is under the control of the PHASE control bus from the digital control circuit. This multiplexer selects any two adjacent oscillator phases (e.g. 0° and 90°) that are connected to the input of a dual monolithic DAC U28. These signals are then scaled by the dac (U28), also under the control of the digital control circuit. The two outputs of this dac are summed by op amp U29. Using this method, the output of U29 is a phase shifted signal between 0 and 360°, where the scaling of the signals phase shift within a 90° range.

Power Amplifier Assembly (A16) *2-139.*

The Power Amplifier assembly outputs dc voltages from ±22V to ± 219.99999V and ac voltages from 22V to 219.99999V rms. The frequency limit for 220V ac output is 100 kHz. Output voltage limits are derated at frequencies above 100 kHz. At 1 MHz, the maximum output voltage is 22V rms. The Power Amplifier drives the High Voltage assemblies (A14, A15) in all high voltage and high current functions.

This assembly also contains calibration circuitry that enables the internal calibration system to determine exact Power Amplifier ac and dc gain, offsets and frequency response.

The main sections of this assembly are the input stage, mid stage, output stage, sense-current cancellation circuit, the dc and ac gain calibration circuits, and the Power Amplifier Digital Control SIP assembly (A16A1), which is mounted on the Power Amplifier assembly.

Power Amplifier Digital Control Sip Assembly (A16A1) *2-140.*

Digital control for the Power Amplifier assembly is contained on the SIP assembly (A16A1) mounted at the bottom of the Power Amplifier. This assembly configures the Power Amplifier assembly for its various modes of operation. (Also see "±PA Supplies Digital Control" in the Power Amplifier Supply theory of operation.)

The heart of the Digital Control assembly is an 82C55 Programmable Peripheral Interface IC (U11) operating under software control via the guarded digital bus. This IC has three ports that generate 24 outputs. These outputs control two 5801 relay driver ICs (U10, U12), two LM339 Comparators (U13, U15) and an analog multiplexer (U14) used for diagnostics.

Relay driver U10 generates eight control lines (LC0*-LC7*) that control four latching relays (K1-K4). Relay driver U12 generates eight control lines (C0*-C7*) for non-latching relays K10-K17. C0* also controls FETs Q57 and Q58. Port A (PA0-PA7) from U11 provides an input bus common to relay drivers U10 and U12. Each driver has separate strobe and enable lines from port C of U11. Driver U10 is strobed by PC7 and enabled by PC5. Driver U12 is strobed by PC4 and enabled by PC6. When a STROBE line is selected, data on the bus (PA0-PA7) is strobed into the respective driver chip. When an ENABLE is selected, this strobed data appears at the output, thereby energizing the appropriate relays. Latching relays only need to be energized for 10 ms; non-latching relays need to be energized continuously.

As an example, the following steps are taken to set up latching relays controlled by relay driver U10.

1. Write the proper data for these relays to port A of the 82C55 (U11).
2. Write hex A to PC4-PC7 to strobe the data into U10.
3. Write hex 0 to PC4-PC7, wait 10 ms and write hex 2 to PC4-PC7. This takes U10's output out of tri-state and energizes the proper relay coils for 10 ms. Since PC4 and PC6 are always low, U12 is undisturbed.

Two LM339 quad comparators (U13 and U15) get their data from port B of U11 (PB0-PB7) and generate control lines SW0-SW7. SW0-SW2 are inputs to decoder U9, which generates eight additional control lines (CONT0*-CONT7*) for controlling FETs and solid state switches. Control line SW3 controls FETs Q50 and Q51. Control lines SW4-SW7 are routed through the motherboard to the Filter/Power Amplifier Supply assembly (A18) to control the +PA and -PA supplies.

The diagnostic circuit enables the Calibrator to monitor eight diagnostic (MUX) signals on the Power Amplifier assembly. A 4051 analog multiplexer (U14) is controlled by PC0-PC3 from U11. This multiplexer selects of the eight MUX signals to the SDL line, where it is measured by the adc circuit on the DAC assembly (A11). Resistor network Z2 and various resistors and zener diodes on the Power Amplifier assembly divide these MUX signals down to a proper level for measurement by the adc circuit. The eight monitored points are:

- MUX0 Output of U7; indicates the status of the amplifier loop
- MUX1 +PA Supply
- MUX2 -PA Supply
- MUX3 Power Amplifier output

- MUX4 Indicates the temperature of the Power Amplifier assembly
- MUX5 Power Amplifier dc input
- MUX7 Diagnoses the state of the hybrid heater-control circuit

PA Common Circuitry 2-141.

Common circuitry consists of the +PA and -PA supplies, input stage, mid stage, and the output stage. These four circuits are described under the next four headings.

Power Amplifier input node, gain, and feedback are different for dc and ac operation. Power Amplifier gain is -20 in the dc function, determined by the ratio of resistor network bonded to the HR8 assembly (500 kΩ/25 kΩ). Gain in the ac function is -10, which is determined by the ratio resistors [(R11 + R12 + R13)/R17]. This is described in more detail under "DC Voltage Function" and "AC Voltage Function".

+PA and -PA Supplies 2-142.

The ±PA supplies are high voltage supplies generated by the Filter/PA Supply assembly (A18). These supplies can be controlled by the Digital Control SIP assembly (A16A1) and are switched between the two modes shown in Table 2-13.

- ±185V
- ±365V

Theory of operation for the Filter/PA Supply assembly (A18) describes how these voltages are generated and selected.

Table 2-13. PA and -PA Supply Settings at Different Outputs

Calibrator Output	+PA	-PA
Less than 22V ac or dc	+185V	-185V
22 to 110V dc	+185V	-185V
110 to 220V dc	+365V	-185V
-220 to -110V dc	+185V	-365V
22 to 101V ac (freq < 120 kHz)	+185V	-185V
22 to 85V ac (freq > 120 kHz)	+185V	-185V
Other voltages	+365V	-365V
220 to 550V dc or ac	+185V	-185V
550 to 1100V dc or ac	+365V	-365V
220 mA to 2.2A	+365V	-365V

PA Input Stage 2-143.

The input stage consists of a heater-controlled hybrid HR8, op amp U7, transistor Q6, and JFET Q2. The HR8 assembly consists of an op amp mounted on a heated-substrate hybrid, with a resistor network bonded to it. Hybrid HR8 provides the input stage with excellent dc characteristics of low offset, noise and drift. The hybrid heater-control circuit (on sheet 3 of the schematic) adjusts the base voltage of Q38 to deliver the correct current to the heater resistor. This maintains the hybrid assembly at a constant temperature in spite of environmental temperature variations. Transistor Q35 protects the hybrid in case Q38 fails. Input of the hybrid op amp is protected by CR13 and CR14. Output of the hybrid op amp is connected to the input of a faster op amp (U7), which provides additional dc gain and a higher slew rate. JFET Q2 and transistor Q6 combined with these two op amps complete the input stage. Q2 is a very low-bias-current, high-frequency JFET.

In mid to high-frequency operation, Q2 is effectively the only path for the input stage signal. HR8 and the U7 op amps are bypassed at these frequencies by R89, C42, R24, and C12. As a result, the base of Q6 is at ac ground. In dc to mid-frequency operation, the gate of Q2 is at ground potential. At any frequency, the potential difference between the gate of Q2 and the base of Q6 results in a current through Q6 as determined by R22, and by the transconductance of Q2 and Q6. The input stage is called a transconductance stage because an input voltage results in a current output at the collector of Q6.

This current output is coupled to the mid stage (Q12, Q14, and Q16) by Q8, Q9, Q13 and C15, where it results in a voltage across the base-emitter of Q16 (the input of the mid stage). Current source Q9 determines bias current in Q2 and Q6. Variations of Q6 output current become voltage variations at the base of Q16. This transfer is through Q8 and Q13 at dc and low frequencies, and through C15 at high frequencies.

The input stage operates with low voltage supplies (±17V) whereas Q16 of the mid stage is connected to the -PA supply, which can be as high as -365V. This potential difference is dropped across level shifter Q13.

PA Mid Stage *2-144.*

The mid stage (Q12, Q14, and Q16), biased by the 8 mA current source (CR53, Q31, Q32 and R87 on sheet 2 of the schematic), is a voltage amplifier providing additional gain. The base of transistor Q16 is the input to the mid stage. MOSFETs Q12 and Q14 are biased by R41 and R53 respectively. Components CR21, CR23, and VR22 protect Q12 from excessive source-to-gate voltage, and R112 prevents Q12 from oscillating. Components CR25, CR29, VR28, and R113 perform the same function for Q14. A signal at the base of Q16 appears amplified at the drain of Q12. Total impedance from the drain of Q12 to ground, divided by R58, determines gain at dc and low frequencies. At high frequencies, the effective drain to ground impedance is R53. Relay K12A parallels C18 and C57 during dc operation for a lower bandwidth. Capacitors C18 and C57 provide the Miller capacitance for the amplifier.

Transconductance gain of the input stage and the Miller capacitance determine Power Amplifier frequency response at high frequencies. All the voltage gain of the Power Amplifier comes from the input and mid stages.

PA Output Stage *2-145.*

The Output Stage is an emitter follower that provides current gain but no voltage gain. It is needed because the mid stage cannot drive the rated load by itself.

Voltage across R74 and R35 determines the bias current through the output stage. This voltage equals the voltage across Q7, minus the value (4 x Vbe) (for each transistor Q4, Q5, Q10, and Q11). Transistor Q7 is configured as a Vbe multiplier, the voltage across which (and thus the output stage bias current) is the value (1 + (R23+R26)/R32). The output bias current is 50 mA.

NMOSFETs Q1, Q3, and transistor Q5 source current, while PMOSFETs Q15, Q17, and transistor Q10 sink current from the load. This output stage can drive up to 50 mA of load current as determined by the current limit circuit on ±PA supplies on the Filter/PA Supply assembly (A18).

Zener diodes VR15 and VR18 bootstrap MOSFETs Q3 and Q15 respectively, and provide the power supplies SC+ and SC- to op amp U1 in the sense current cancellation circuit. Two stacked NMOSFETs (Q1, Q3) on the top end (+PA side), and two stacked

PMOSFETs (Q15, Q17) on the bottom end (-PA side) withstand the high voltage drops between ±PA supplies and output. NMOSFETs Q1 and Q3 are biased by R15 and R19 respectively. PMOSFETs Q15 and Q17 are biased by R52 and R57 respectively. Components CR5, CR7 and VR6 protect Q1 from excessive source-to-gate voltage and R108 prevents Q1 from oscillating. Protection is also provided for remaining MOSFETs in the output stage. Output of this stage, called PA OUT HI, is the output of the Power Amplifier assembly. Components R120 and L10 isolate capacitive loads.

PA Sense Current Cancellation Circuitry *2-146.*

During dc operation of the Power Amplifier, sense current in the 500 kΩ feedback resistor (on the resistor network in the HR8 assembly) can cause an output error because of the finite resistance path of the connection to the load. Op amp U1 eliminates this error by feeding an equal and opposite current in this path. The magnitude of this current is determined by PA OUT HI, which is connected to the non-inverting input of U1. This circuit generates a current through R8, which is equal to current flowing through the 500 kΩ feedback resistor. Sense-current cancellation is active only in dc 220V range.

PA in Standby *2-147.*

The Power Amplifier schematic shows all relays and DG211 FET switches in the standby condition. The Power Amplifier 25 kΩ input resistor and R17 are tied to OS COM through Q39 and R118. Power Amplifier output is close to zero and the whole loop is stabilized.

To better understand Power Amplifier configuration in the ac/dc 220V range, refer to Figure 2-22.

PA Operation: 220V DC Range *2-148.*

During dc operation, Power Amplifier gain is -20, as determined by the 500 kΩ/25 kΩ resistor network on the HR8 assembly. Control line SW3, inverted by U8, turns on Q51. This references the +input of the precision op amp in the input stage to R COM. The DAC assembly is set to the negative 11V range and its outputs, DAC OUT HI and DAC SENSE HI, are connected to pin 2 of the resistor network on the HR8 assembly by relay K2. The sense current cancellation circuit is active during dc operation. Its output, SIG1, is connected to the resistor network feedback resistor pin 1 by relay K15A. The amplifier has a much lower bandwidth in this mode because of the much higher Miller capacitance in C57. Lower bandwidth results in lower amplifier noise.

The output signal, PA OUT HI, is routed to the High Voltage Control assembly (A14), where it goes through relay K10 and becomes PA OUT DC. PA OUT DC is routed to the Switch Matrix for connection to the OUTPUT HI binding post. The sense signal, PA SENSE DC from the Sense Current Cancellation circuit, is routed to the Switch Matrix assembly (A8) for connection to the OUT/SENSE HI or SENSE HI binding posts, thus making the binding post the sense point in internal sense and allowing for external sense through the SENSE HI binding post.

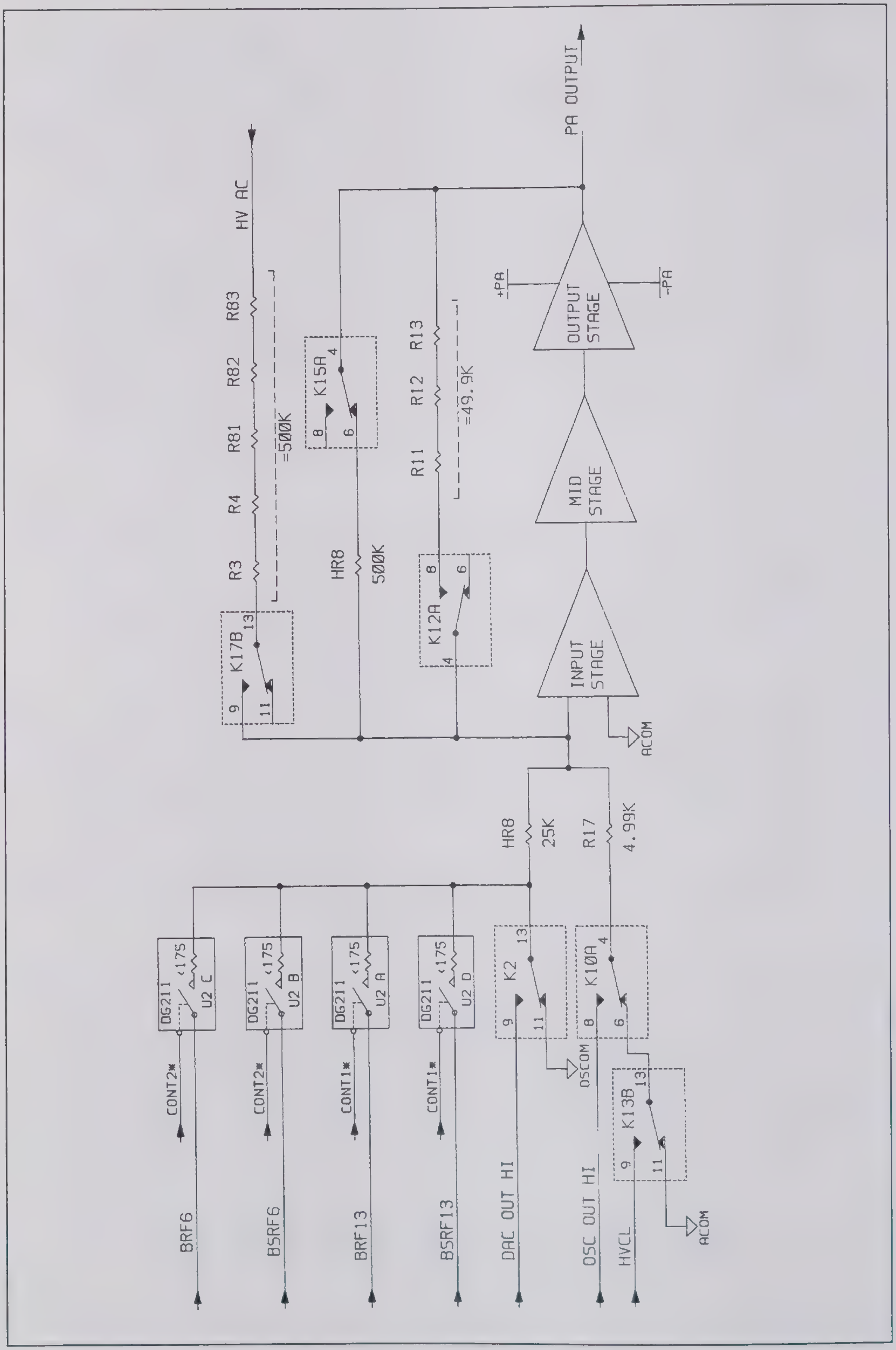


Figure 2-22. Power Amplifier Simplified Schematic

PA Operation: 220V AC Range *2-149.*

During ac operation, Power Amplifier gain is -10 as determined by the 4.99 kΩ input resistor R17, and 49.9 kΩ feedback resistors (R11 + R12 + R13). Control line SW3 turns Q50 on, which references the +input of the precision op amp in the input stage to OS COM. The Oscillator assembly (A13) is set to the 22V range and its output OSC OUT HI is connected to the input resistor R17 by relay K10A. The Power Amplifier output is connected to the feedback resistors R11-R13 by relay K12B.

The Power Amplifier output is attenuated by a precise 1/100 by 220V range ac attenuator. The attenuated signal is connected to OSC SENSE HI, where it is sent to the Oscillator Control assembly (A12). The Oscillator Control assembly regulates the Oscillator Output so that an exact calibrated ac signal appears at OSC SENSE HI. Since the 220V range ac attenuator is completely characterized (as explained below), the exact desired signal appears at PA SENSE AC and hence at the appropriate sense point at the output.

The 220V range ac attenuator circuit contains op amp U4, a 400 kΩ/4 kΩ resistor network Z1, and transistor Q54. PA SENSE AC, which is connected to PA OUT HI at the load, is connected to the 400 kΩ input resistor (pin 1) of Z1 by relay K16. The 400 kΩ/4 kΩ node (pin 3) of Z1 is connected to the inverting input of U4.

During ac operation, control line C0* is inverted by U8, which turns on Q58 to connect the non-inverting input to OSC RCOM. Transistor Q54 supplies current gain for the output of U4 to drive the capacitance of the OSC SENSE HI line. This voltage is connected to the 4 kΩ feedback resistor (pin 4) of Z1. The output is connected to OSC SENSE HI by relays K10B and K11. The dc feedback 500 kΩ/25 kΩ resistor network and the sense-current cancellation circuitry are disconnected by energizing K15.

The sense signal, PA SENSE AC, and the output signal, PA OUT HI, are routed to the High Voltage Control assembly (A14), where relays K10, K13, and K3 connect them to HV SENSE and HV OUT. HV SENSE and HV OUT are connected to the binding posts by the motherboard relays in the same manner as in the 1100V high voltage mode. Refer to the High Voltage assembly theory of operation for more information.

High Voltage Assembly Support Mode *2-150.*

High Voltage AC 1100V Range 2-151.

During high voltage ac operation, the output of the Power Amplifier is routed to the input of a step up/down transformer on the High Voltage Control assembly (A14). Overall gain from the Oscillator Output to the High Voltage Output is -100 as determined by the 4.99 kΩ input resistor R17, and 500 kΩ feedback resistor (R3 + R4 + R81 + R82 + R83). Relay K10A connects the ac signal OSC OUT HI from the Oscillator Output assembly to input resistor R17. Relay K12 remains open as shown on the schematic, while K15 is energized to remove feedback used in 220V-dc operation.

Output from the High Voltage Control assembly, called HVAC on the schematic, is connected to the feedback resistors. Relay K17B is energized to close the feedback loop. Control line SW3 is high, which turns Q50 on and turns Q51 off. Because sensing back to the Oscillator Control assembly is done by the High Voltage/High Current assembly, the output of the 220V range ac attenuator is disabled from OSC SENSE HI by relay K11.

High Voltage DC 1100V Range and Current 2.2A Range 2-152.

Operation of the Power Amplifier is the same for the 1100V dc and the 2.2A current functions. In these functions, the output of the Power Amplifier is routed to a step up/down transformer on the High Voltage Control assembly (A14). The Power Amplifier is configured the same as for 220V ac operation, except that the input is the square-wave signal HVCL from the High Voltage Control assembly, rather than OSC OUT HI, through relays K13B and K10A.

220V DC Internal Calibration Network *2-153.*

The 220V dc internal calibration network determines the exact gains and offsets of the power amplifier. This circuit uses part of the resistor network HR8 as the input attenuator, and uses op amp U9, and zener diodes VR57 and VR58. Relay K4 connects the output of this circuit to the RCL line.

Zener diodes VR57 and VR58 reduce the power supplies for chopper-stabilized amplifier U9, which is used as a voltage follower.

PA Calibration *2-154.*

The following paragraphs describe how the Power Amplifier assembly is calibrated during the internal portion of calibration, or calibration check. This process calibrate the offset, gain, and frequency characteristics of the Power Amplifier.

The instrument measures the offset of the main amplifier (220V range). The DAC output is amplified by the Power Amplifier, which is configured for the dc 220V range, and its output connected to the internal cal zero amplifier located on the Switch Matrix assembly. Output of this internal cal zero amplifier is channeled to the DAC's adc amplifier circuit by the RCL line. Input of the internal cal zero amplifier is first connected to R COM where a checkpoint reading is taken by the DAC's adc circuit. The output of the Power Amplifier is then connected to the input of the internal cal zero amplifier and the DAC output is adjusted to the checkpoint reading out of the zero amplifier. This adjusted DAC output is a measure of the offset of the Power Amplifier. Also, refer to the Switch Matrix theory of operation.

The 175 kΩ/25 kΩ (internal cal) resistor network located on HR8 is calibrated next (see Figure 2-23). First the offset of the 220V dc internal cal amplifier is measured. This is done by connecting pin 6 of 175 kΩ/25 kΩ resistor network to RCOM by relay K1, and pin 7 to ACOM by U5C and relay K3. ACOM is connected to RCOM through 051 during this step. Output of this internal cal amplifier is connected to the RCL line by relay K4, where it is measured by the adc circuit on the DAC assembly. As before, the DAC's output needed to obtain the checkpoint for this step represents the offset of the internal calibration amplifier.

Resistor network attenuation is calibrated next. Components U5A, U5D and K3 connect BSRF13 and BRF13 to the 175 kΩ end, while K1 connects R COM to the 25 kΩ end of the resistor network. The resulting 1.625V at the output is connected to the RCL line by relay K4, where it is connected to the +input of the adc amplifier circuit on the DAC assembly. The DAC output is connected to the adc circuit -input, and adjusted until the checkpoint reading is obtained. The exact value of this voltage is now known, so the system software computes the exact attenuator ratio from this known voltage, BSRF13 value, and the previous offset measurement.

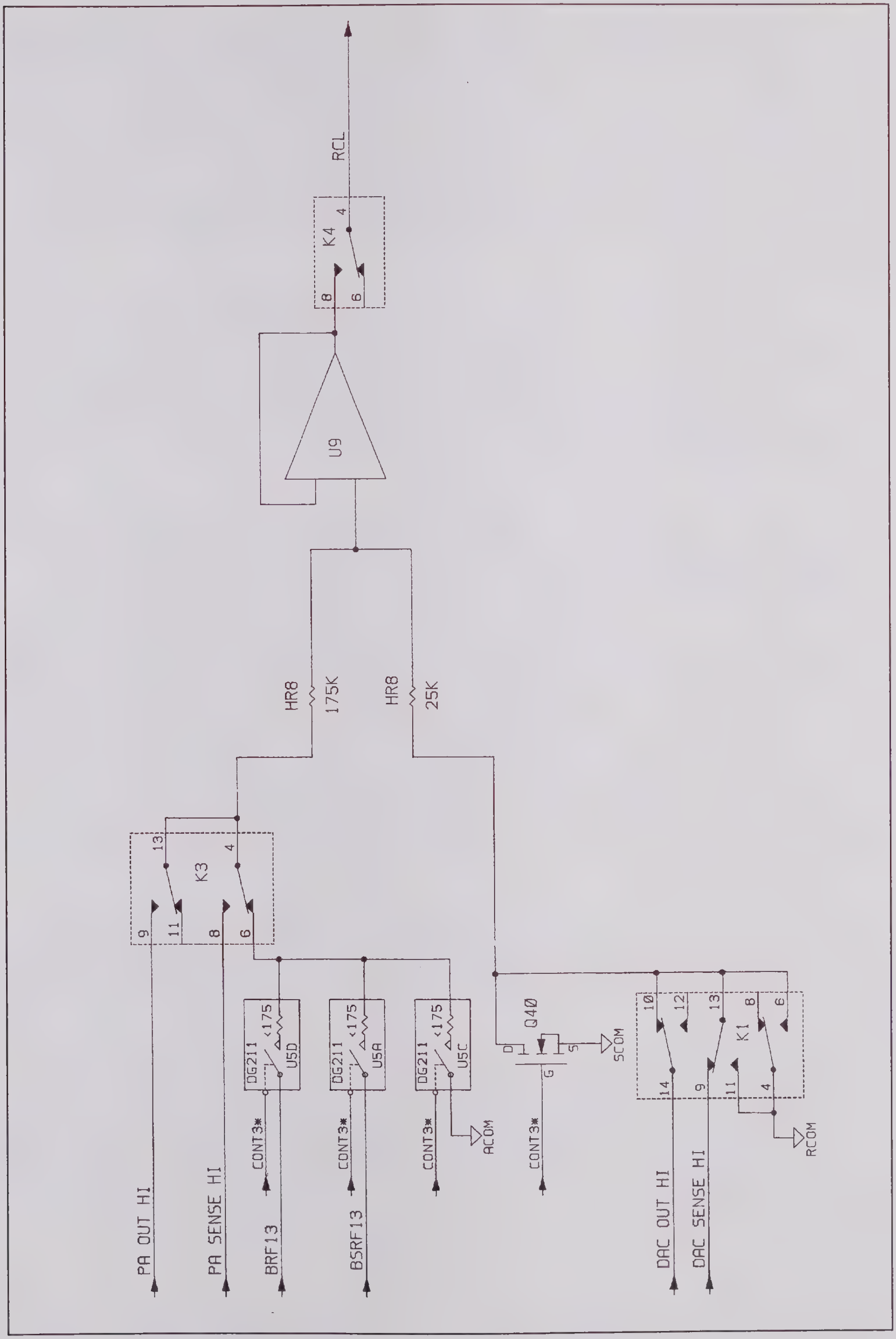


Figure 2-23. Power Amplifier DC Calibration Network

Power Amplifier dc gain of approximately -20 is calibrated next. The Power Amplifier is configured as in the 220V dc operation, except the input is connected to the DAC's 6.5V reference BRF6 and BSRF6 by U2C and U2D respectively. The resulting -130V at the Power Amplifier output is connected to the 175 kΩ end of the internal cal resistor network by relay K3. The 25 kΩ end of this network is connected to DAC OUT HI and DAC SENSE HI by relay K1. The output of the internal cal amplifier is connected to the DAC's adc circuit as in the previous steps, and the DAC OUTPUT is adjusted until checkpoint is measured by the adc circuit. Since the exact attenuation of the resistor networks is already known, the exact Power Amplifier output voltage can be calculated. This in turn gives the exact Power Amplifier dc gain, since the exact value of 6.5V reference BSRF6 is known.

Attenuation of the 220V range ac attenuator (U4 and 396 kΩ/4 kΩ resistor network Z1) is calibrated next. This is illustrated in Figure 2-24. First, the offset of the attenuator circuit is measured by connecting the non-inverting input of U4 to ACOM through Q57 and thus to RCOM through Q51. Then, the Power Amplifier is configured for the 220V dc range with its inputs connected to the DAC's 6.5V reference BRF6 and BSRF6 by U2B and U2C respectively. The resulting -130V is connected to the 400 kΩ input resistor (Z1) of the 220V range ac attenuator by relay K16.

The +1.3V from the output of the attenuator circuit is connected to the RCL line by relays K10B and K11. This voltage on the RCL line is connected to the +input of the adc amplifier circuit on the DAC assembly. The DAC output is connected to the -input of the adc amplifier circuit, and is adjusted until a null is achieved. The exact value of this voltage is now known so the system software can compute the exact attenuator ratio.

The 220V range ac attenuator's attenuation ratio can vary over the frequency range. This variation can be accounted for if the frequency response of this network is characterized at a few spot frequencies. This is done by connecting the Power Amplifier output, which is set to 22V, to the AC CAL line by relay K14. The AC CAL line goes into the AC/AC CAL thermal sensor located on the Oscillator Control assembly. The Power Amplifier output of 22V is also attenuated through the AC Attenuator and sensed by the Oscillator Control via OSC SENSE HI. The Oscillator adjusts its output, and hence the Power Amplifier output, until the ac/ac cal thermal sensor measures the same ac level for all these spot frequencies. The signal levels at OSC SENSE HI are stored in software at all such points.

The ac/ac cal thermal sensor located on the Oscillator Control assembly has a flat frequency response. The change in the ac attenuator's output at various frequencies for a constant thermal sensor output defines the frequency response of the Power Amplifier ac attenuator. These computed ac attenuator factors are stored in the system memory and are taken into account when the calibrator is configured to output ac voltages from the Power Amplifier.

Output stage current is limited to about 250 mA; Q60 limits the current soured by the output stage, and Q61 limits the current the output stage has to sink. Transistor Q62 limits the current flowing through the middle stage. These current limits both protect the power amplifier circuitry and improve power amplifier transient response. Diode CR64 is a current source that maintains a current flow of at least 5 mA through the output devices at all times.

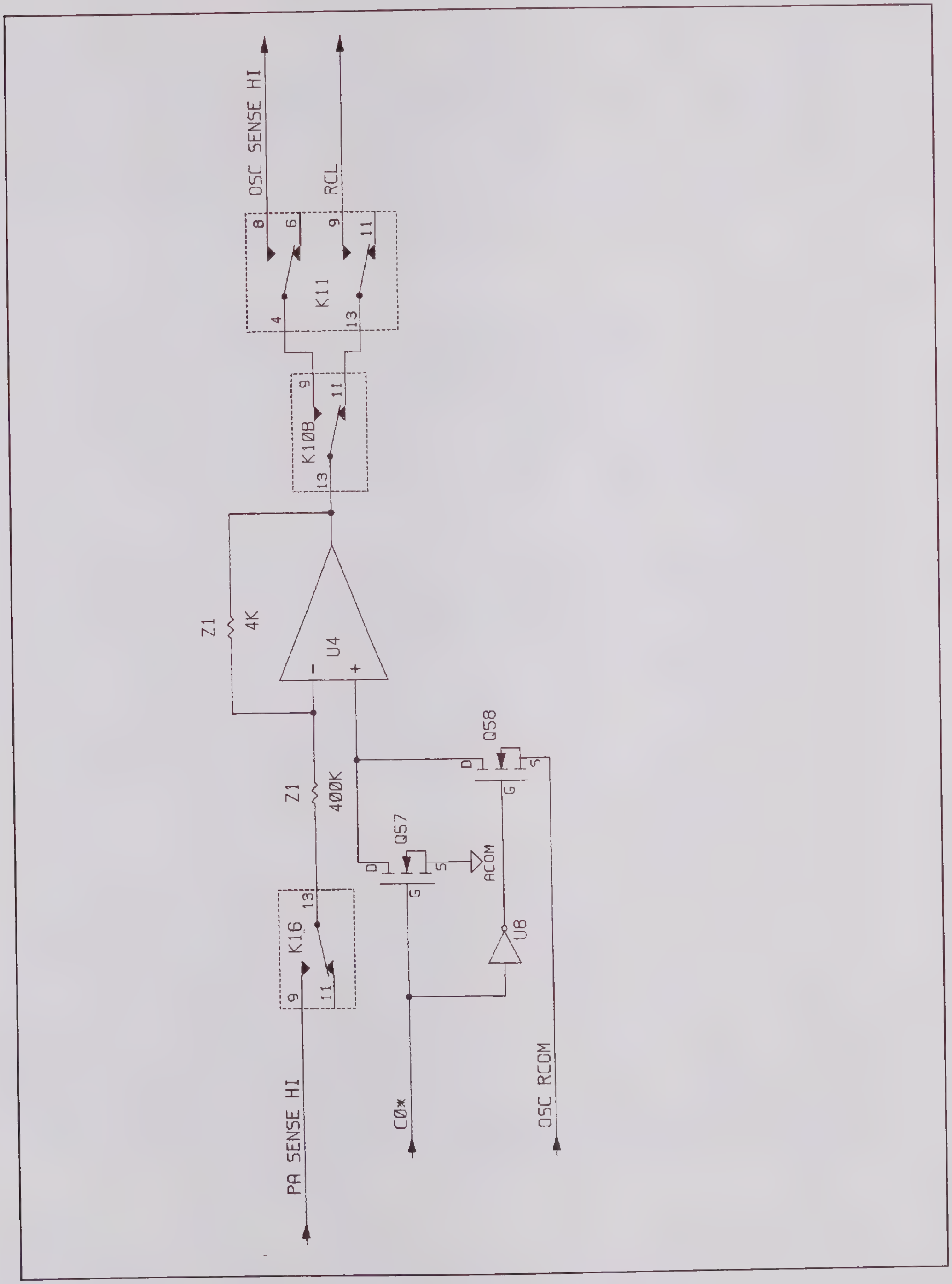


Figure 2-24. Power Amplifier Calibration AC Attenuator

High Voltage Assemblies (A14 and A15) 2-155.

The High Voltage/High Current assembly (A15) and the High Voltage Control assembly (A14) are used in with conjunction with other assemblies in the calibrator to generate the ±1100V dc, 1100V ac, and the 2.2A ranges. The two assemblies work together in generating these ranges. This theory of operation explains how these ranges are generated and discusses the individual circuits on each assembly. Refer to the High Voltage/High Current assembly simplified schematics (Figures 2-24 through 2-28) or the schematic diagram to understand this theory of operation better.

1100V AC Range 2-156.

Refer to Figure 2-25 for the following discussion. The ac signal generated by the Oscillator Output assembly (A13) is amplified by the Power Amplifier assembly (A16). The output of the Power Amplifier, PA OUT DC, is routed to the High Voltage Control assembly (A14), where it is further amplified by transformer T1 to generate the 1100V ac range. This high voltage signal from T1 is also the feedback signal to the Power Amplifier assembly. Relays K14-K16 connect the transformer windings in series during operation below 120 Hz.

Line PA OUT DC is connected to one side of the primary winding of step-up transformer T1 by relay K1 on the High Voltage Control assembly (A14). The other side of the primary winding is tied to PA COM through R67. One side of the secondary winding is tied to PA COM by relays K9 and K6. The other side of the secondary winding, the high voltage ac signal, is connected to HV OUT by relays K5, K12 and K3. Line HV OUT is connected to the OUTPUT HI binding post by relays K9 and K1 on the motherboard.

This high voltage ac signal is also connected to HVAC by relay K5. Line HVAC is the feedback signal to the Power Amplifier assembly. During high voltage operation, the input resistance of the Power Amplifier assembly is 5 kΩ. Line HVAC is connected to the feedback resistance, which is a series of resistors totaling 500 kΩ. This creates a gain of 100 to the Oscillator Output.

The SENSE HI binding post is connected to HV SENSE by relays K3, K2, and K10 on the motherboard. HV SENSE, which is tied to HV OUT at the load, is connected to INT HV SNS by relay K13 on the High Voltage Control assembly (A14). INT HV SNS is routed to the High Voltage/High Current assembly (A15), where it is connected to the ac sense buffer circuit by relay K6. This circuit attenuates the high voltage signal by 100 and connects it to OSC SENSE HI through relay K4B. The level of attenuation is determined by the 7 MΩ input and 70 kΩ feedback resistors on the HR7 assembly. OSC SENSE HI is used by the Oscillator Output assembly, which adjusts its output signal to maintain an exact feedback signal level. HV OUT and HV SENSE are routed to the High Voltage assembly (A15) where components CR9, CR10, and R33-R35 keep the voltage difference between them at 0.7V should they become disconnected at the load. Relay K11 connects HV OUT to HV SENSE during calibration in the ac function.

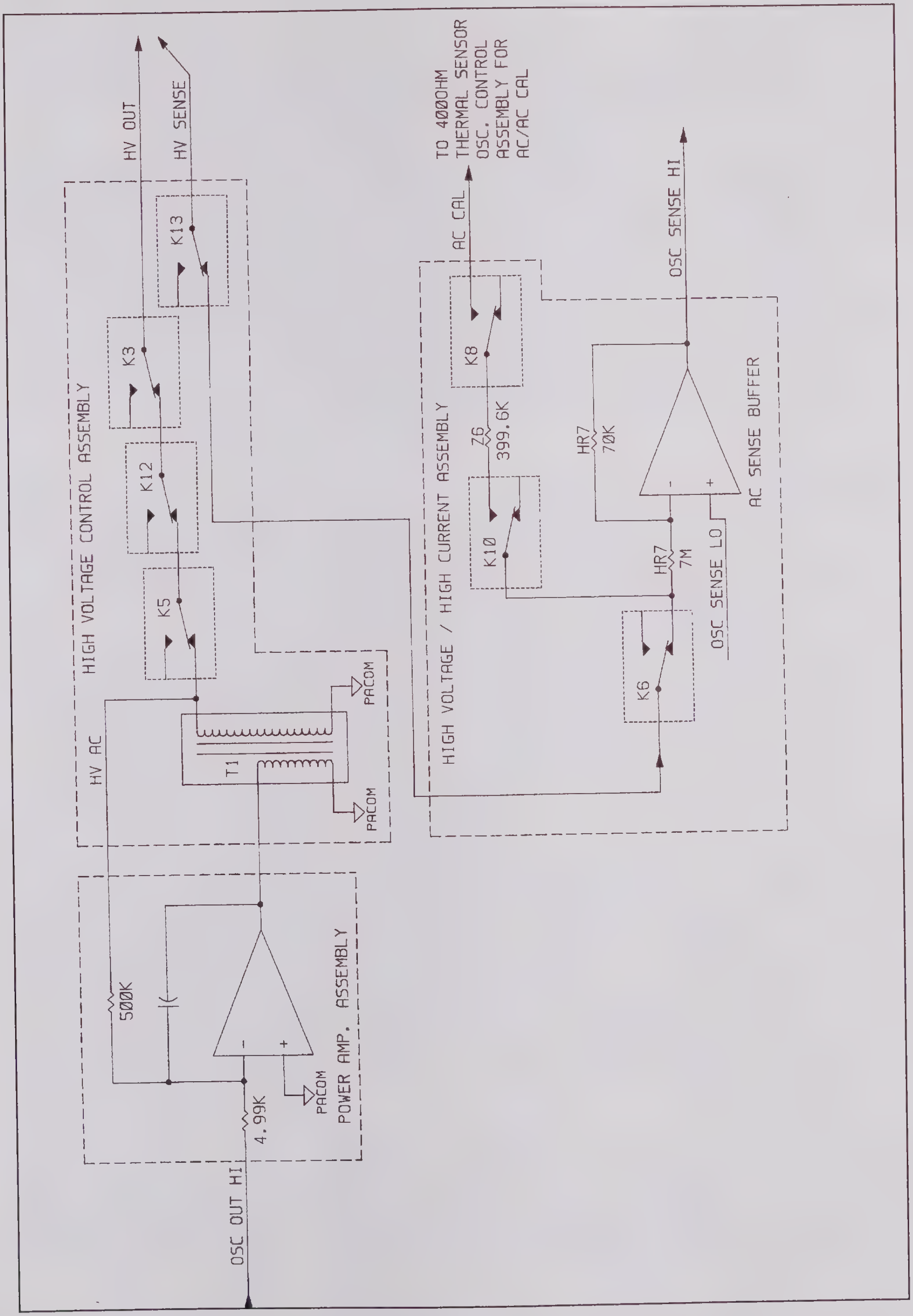


Figure 2-25. High Voltage/High Current Assembly 1100V AC Range

1100V DC Range *2-157.*

Refer to Figure 2-26 for the following discussion. The High Voltage assembly (A15) amplifies the output of the DAC assembly (A11), set to the 11V range, by a gain of -100 to generate the 1100V dc range.

For operation in the 1100V dc range, DAC OUT HI and DAC SENSE HI from the DAC assembly, set to the 11V range, are tied together and connected to the input of the dc HV amplifier circuit by relay K1. The dc HV amplifier circuit, the HV dc output series pass and current limit circuit, and the HV dc power supply circuit on the High Voltage Control assembly (A14) constitute an overall amplifier with an inverting gain of 100. This gain is determined by the 70 kΩ input and 7 MΩ feedback resistors on the HR7 assembly.

High voltage dc output, generated on the High Voltage Control assembly (A14), is obtained by filtering an approximate trapezoidal wave. The overall loop gain of this amplifier divides this ripple so the high voltage dc output is clean and stable.

Signal routing to the front panel binding posts is done in the same manner as the ac 1100V range.

HVDC Power Supply Filter Circuit *2-158.*

The high voltage dc power supplies are generated by the High Voltage Control assembly (A14) in conjunction with the Power Amplifier assembly (A16). The High Voltage Control assembly generates an amplitude-controlled square wave, HVCL, from the magnitude control circuitry. The magnitude control circuit contains all the circuitry on sheet 2 of the High Voltage Control assembly schematic.

Signal HVCL is amplified by the Power Amplifier assembly with its output, PA OUT DC, connected to one side of the primary winding of transformer T1 by relay K1. The other side of the primary is connected to PA COM by R67. The secondary windings of T1 are connected to bridge rectifier CR1-CR4 by relays K9 and K6. The dc voltage from this rectifier is called +HVDC and -HVDC. Resistors R3-R5 form a 600 kΩ bleeder resistor for C1. Line HVDC is selected between +HVDC and -HVDC by relays K4 and K11. Line HVDC is connected to HV OUT by relays K5, K12 and K3.

During operation with a negative DAC voltage and a positive output from the High Voltage/High Current assembly, +HVDC is connected to HV OUT by relays K4, K11, K5, K12 and K3. +SP C is created from -HVDC by relays K4 and K8. During operation with a positive DAC voltage and a negative output from the High Voltage/High Current assembly, -HVDC is connected to HV OUT by relays K4, K11, K5, K12 and K3. -SP C is created from +HVDC by relays K4 and K8. Zener diodes VR4 and VR5 keep -SP C and +SP C, respectively, from exceeding 16V. The dc voltage level of +SP C and -SP C is controlled by the HV dc output series pass and current limit circuit on the High Voltage/High Current assembly. This in turn controls the magnitude of HVCL which sets the level of HVDC.

HV DC Output Series Pass and Current Limit Circuit *2-159.*

The HV dc output series pass circuit controls the level of +SP C when the high voltage output is positive, and -SP C when the high voltage output is negative. Typically +SP C and -SP C are approximately ±6.8V dc with ripple equal and opposite polarity from the HVDC ripple.

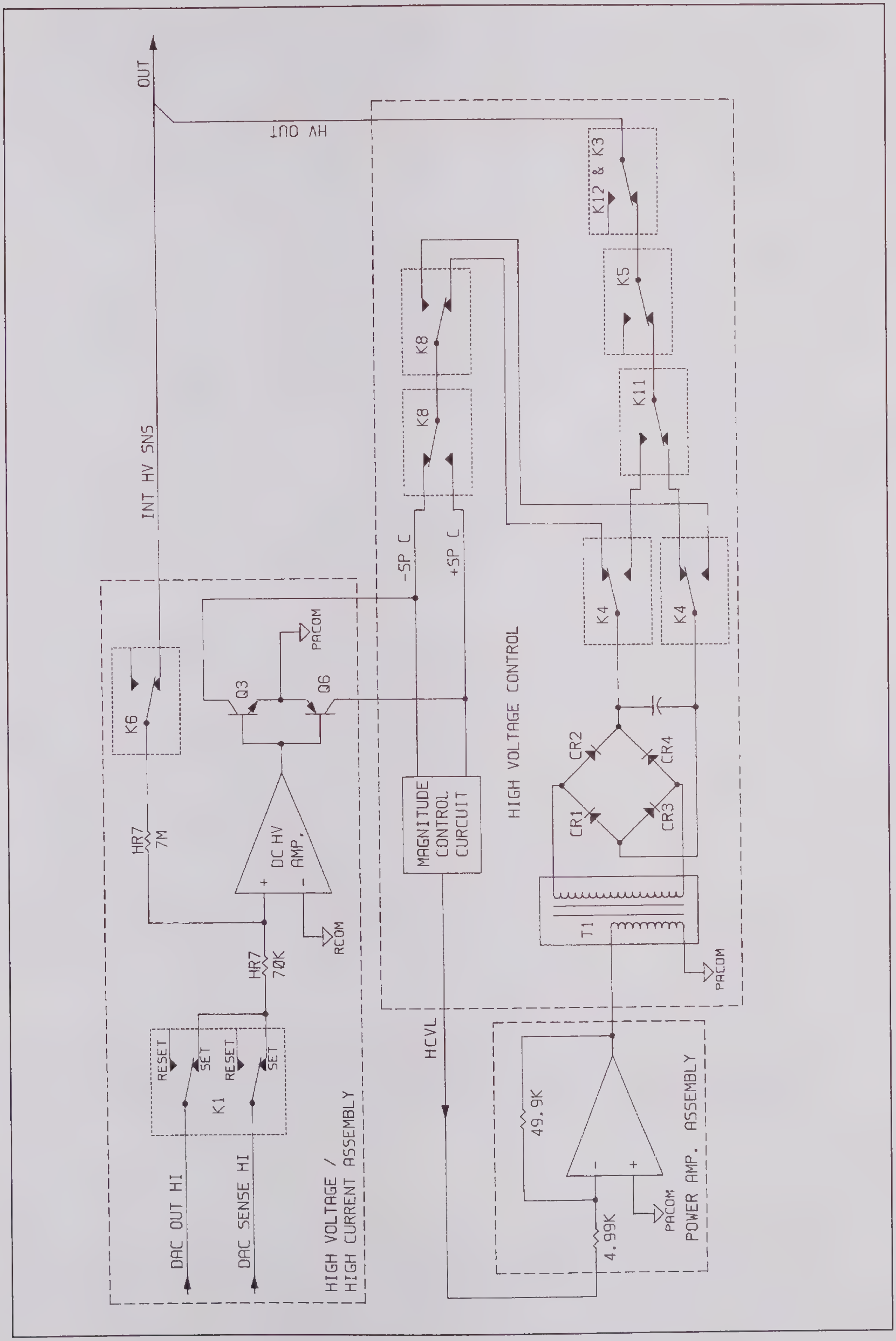


Figure 2-26. High Voltage/High Current Assembly 1100V DC Range

When the DAC assembly is set to the +11V range, the output from the High Voltage assembly (with a gain of -100) is in the -1100V range. In this mode, -SP C is connected to the collector of transistor Q3. The output from the dc HV amplifier follows a change in the output voltage from the DAC assembly. This change controls how much Q3 is turned on or off. As the DAC voltage is increased, Q3 turns on pulling -SP C to PACOM. This causes the magnitude control circuit to increase the amplitude of HVCL which increases the output from the Power Amplifier assembly, thus increasing the HVDC until the overall loop is stable.

Operation in the +1100V range is basically the same, with transistor Q6 controlling +SP C in the same manner as above.

Current limiting is provided by Q4 if more than 35 mA is drawn from the output. If this condition occurs, Q4 pulls down CUR LIM, which is routed to the High Voltage Control assembly. (CUR LIM is also called RST.) When CUR LIM (RST) is pulled low, PS OFF goes high to turn off the square wave, HVCL, which shuts down the HVDC supplies. The generation of HVCL is described under the heading, "Magnitude Control".

DC HV Amplifier/AC Sense Buffer *2-160.*

The dc HV amplifier and the ac sense buffer are basically the same circuit. The configuration is changed to provide the 100:1 amplification of dc voltage and the 100:1 attenuation of the high voltage ac signal. This is defined by the way the HR7 resistor network is configured in the circuit. This configuration is described in the 1100V ac range and 1100V dc range theory.

This circuit contains the HR7 resistor network and the circuitry contained in detail 1 as shown on sheet 1 of the High Voltage (A15) schematic. It is used in both the ac and dc voltage modes. Detail 1 contains the HR7 hybrid assembly which is an op amp mounted on a heated substrate hybrid bonded to a resistor network. The HR7 assembly gives this circuit excellent dc characteristics of low offset, noise and drift. The hybrid heater control circuit adjusts the base voltage of Q8 to deliver the proper power to the heater resistor. This maintains the HR7 assembly at a constant temperature in spite of environmental temperature variations. Transistor Q9 protects the hybrid in case Q8 fails. The output of the HR7 op amp is connected to a faster op amp (U2), which provides additional gain and a high slew rate. The output of U2 is called HVAMP OUT on the schematic.

In the dc voltage function, the output of this circuit, configured as a dc HV amplifier, is connected to the series pass circuit by relay K5B. Relays K5A, K7 and K14 add C4 in parallel with the 7 MΩ feedback resistor in the HR7 assembly to filter the noise. ACOM is connected to RCOM by relay K3.

During operation in the ac voltage function relays are positioned as shown on the schematic. Components VR7 and VR8 provide input protection for the op amp on the HR7 assembly. Op amp U1 is added to the circuit by relays K9, K8B and K6. This op amp inverts HVAMP OUT so that the signal to OSC SENSE HI is in phase with the output of the Oscillator assembly. ACOM is connected to OSC RCOM by relays K3 and K4A.

2.2A Range *2-161.*

Refer to Figure 2-27 for the following discussion. Most of the same circuitry is used to create the ac and dc 2.2A current ranges. The Current assembly (A7) is configured to the 22 mA range and connected to the IHV line which drives the 2.2A amplifier circuit on the High Voltage assembly (A15). This 2.2A amplifier provides a gain of 100 to the 22 mA range from the Current assembly to create the 2.2A range.

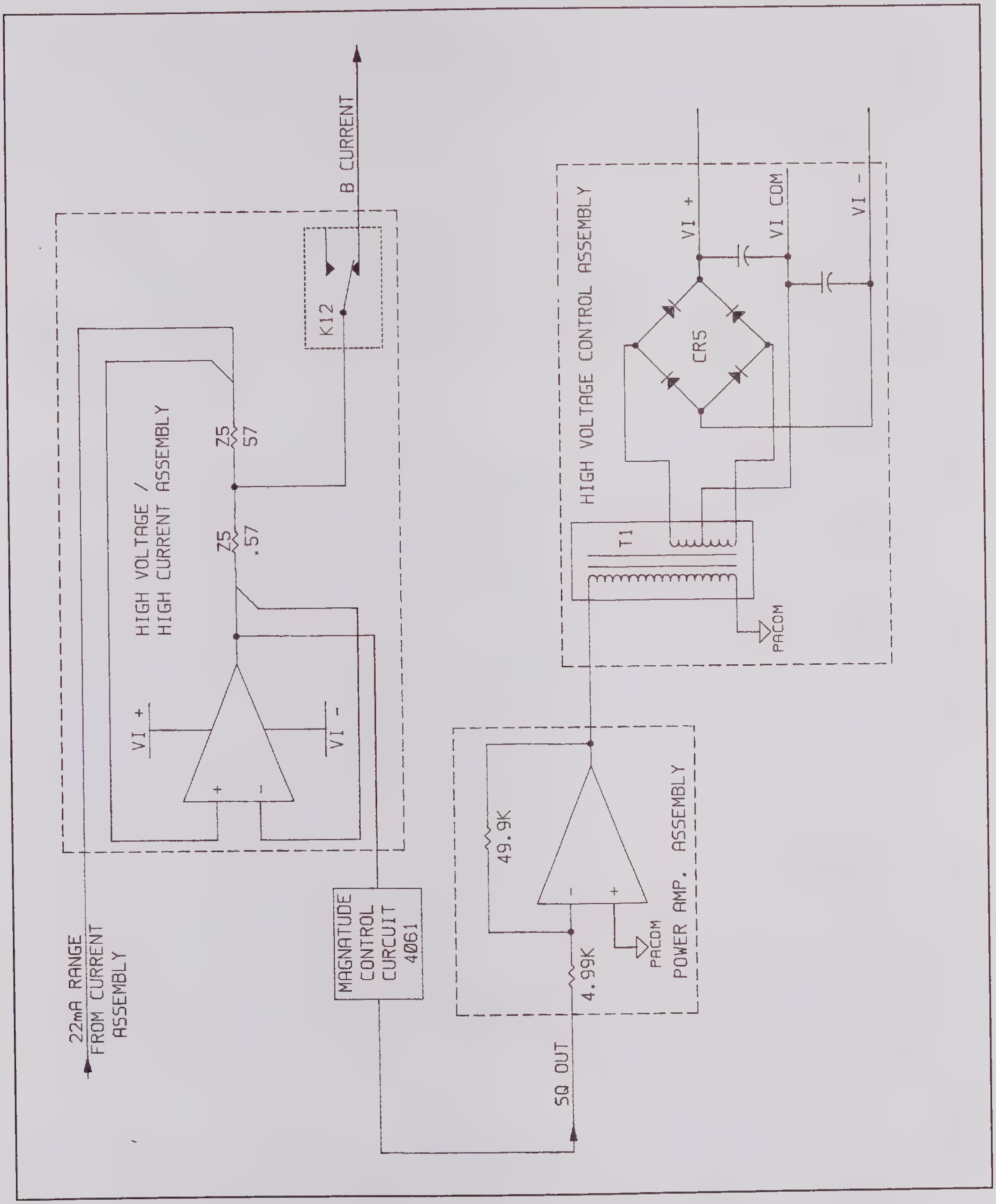


Figure 2-27. High Voltage/High Current Assembly 2.2A AC and DC Ranges

Resistor network Z5 and hybrid H4 determine the performance of the 2.2A range. Current from the A7 assembly develops a voltage across the 57W portion of Z5. The 2.2A current amplifier circuit forces the same voltage across the 0.57W portion of Z5. Because the ratio of these resistors is 100, the current through 0.57W resistor is 100 times that coming from the Current assembly (A7). Relay K12 connects this 2.2A range current to B CUR where it is routed to the Current assembly (A7), which provides the proper relay switching to the front panel binding posts.

The 2.2A amplifier circuit contains the heater-controlled hybrid H4, op amps U3-U5, and transistors Q11-Q16. This circuitry is outlined as detail 2 on sheet 2 of the High Voltage/High Current assembly schematic. The H4 hybrid consists of an op amp mounted on a heated substrate. The heater control circuit adjusts the base voltage of Q18 to deliver the proper power to the heater resistor. This maintains the hybrid at a constant temperature in spite of environmental temperature variations. Transistor Q19 protects the hybrid in case Q18 fails.

The output of the H4 hybrid is a voltage directly proportional to the current output G OUT. Q22 and R72-R76 form a high-frequency path for loop stability. In the ac current function, op amp U3A and its associated circuitry create a half-wave signal equal to the positive peaks of the ac signal from H4. Resistor R47 keeps this half-wave signal approximately 0.7V above 0V. This half-wave signal is then subtracted from the ac signal coming from H4 by op amp U3B and its associated circuitry. This creates a half-wave signal equal to the negative peaks of the ac signal from H4. Resistor R45 keeps this half-wave signal approximately 0.7V below 0V. Transistor Q15 and resistor R50 generate a current from the negative peaks created by U3B. Transistor Q16 and R48 generate a current from the positive peaks created from U3A. The current from Q15 and R50 develops a voltage across the 191Ω resistor (R69). This voltage is used by op amp U4 which drives transistors Q11 and Q12 in the Darlington configuration for current gain. Resistor R67 is the feedback path for U4. The voltage across 191Ω resistor R69 is the same as across the 0.1Ω resistors R68 and R78. Since the value of R68 and R78 is 1000 times less than R69, the current through R68 is 1000 times greater. The current from Q16 and R48 is increased by 1000, in the same manner as previously stated, with op amp U5, resistors R56, R57, and R77, and Darlington-configured transistors Q13 and Q14.

Only half of the circuitry is used, since the output current is either positive or negative in the dc current function. When outputting a positive current, the voltage from H4 is negative. Since there is no positive voltage, the output of U3A is zero, thus no current is developed by R48 and Q16. At this time, the negative voltage from U3B generates an output current in the same manner as in the ac current function. The opposite occurs when outputting a negative dc current.

2.2A Power Supply Filter Circuit *2-162.*

The 2A range power supply filter circuit on the High Voltage Control assembly (A14), operating in conjunction with the Power Amplifier assembly (A16), generates the VI ±supplies used by the 2.2A amplifier circuit on the High Voltage/High Current assembly (A15). The High Voltage Control assembly generates an amplitude controlled square wave, HVCL, from the square wave generator and square wave amplifier circuits. This HVCL is amplified by the Power Amplifier assembly (A16), which is set for a gain of 10. This amplified output, PA OUT DC, is connected to the primary side of transformer T1 by relay K1. The stepped-down secondary voltage is full-wave rectified by CR5 and filtered by C3 and C4 to generate the VI+ and VI- supplies respectively. VI± are low-voltage, high current supplies. These supplies, along with the secondary center tap VI COM, are routed to the High Voltage assembly.

VI+ supplies the output current when sourcing while VI- sinks it. To minimize power dissipation, the magnitude of the VI± supplies is controlled to minimize the emitter to collector voltage on the output stage transistors (Q11, Q14). This is done by controlling the magnitude of the HVCL signal. The controlling function is described later in the Magnitude Control theory.

High Voltage Digital Control *2-163.*

Digital control circuitry on the High Voltage Control assembly (A14) also contains the control for the High Voltage/High Current assembly (A15). The heart of the digital control circuitry is an 82C55 Programmable Peripheral Interface IC (U9), which is under software control via the guarded digital bus. This IC has three ports which generate 24 outputs. These outputs are used to control four 5801 driver ICs (U10-U13), and an analog multiplexer (U14) for self diagnostics.

All relays on both HV assemblies are controlled by drivers U10, U11, U12, and U13. Driver U12 controls relays K14-K16, and generates seven control lines for controlling various FETs and CMOS Analog Switch ICs contained on both assemblies. Port A (PA0-PA7) of U9 provides a common input bus for all drivers. Port C (PC0-PC5) of U9 provides the strobe and enable lines for these drivers. Driver U10, which controls the non-latching relays (K1-K6, K8-K13) on the High Voltage Control assembly, is strobed by PC1. PC0 is inverted by U8C to provide the enable. Driver U11 controls latching relay K7 on the High Voltage Control assembly and latching relays K1-K3 on the High Voltage/High Current assembly. This driver is strobed by PC3. PC2 is inverted by U8D to provide the enable. Driver U13, which controls the non-latching relays on the High Voltage/High Current assembly (K4-K12 and K14), is strobed by PC5 and enabled in the same manner as U10. Driver U12, which generates the Control Lines, is strobed by PC4 and enabled in the same manner as U10. Control line RST, from this driver, is inverted by U8E to create PS OFF. This control line is used by the magnitude control circuit described later.

The diagnostic circuit enables the Calibrator to monitor seven points on either the High Voltage/High Current assembly (A15) or the High Voltage Control assembly (A14). A 4051 analog multiplexer (U14) is controlled by PB4-PB7 of port B of U9. This multiplexer selects which one of these seven voltages are to be applied to the SDL line where it is measured by the adc circuit on the DAC assembly (A11). HV MUX0-HV MUX3 are points on the High Voltage/High Current assembly. HV MUX0 and HV MUX1 monitor the oven temperature of the H4 and HR7 hybrids respectively. The output of the dc HV amplifier/ac sense buffer circuit is divided by R18 and R19 to generate HV MUX2. HV MUX3 monitors the current draw through the HV dc output series pass circuit to detect an overcurrent condition in the high voltage dc mode. Resistors R28 and R27 sense the current for a positive high voltage output and a negative high voltage output respectively. MUX5-MUX7 are points on the High Voltage Control assembly. MUX5 monitors the high voltage output. HV OUT is divided by R9-R13 and R64.

This divided output is connected to the output peak measure circuit which uses op amp U1B. In the dc V function, this circuit is a voltage follower. In the ac voltage function, this circuit is a peak detector.

The output of U1B charges C5 with R17 being the discharge path. This provides a positive dc voltage at MUX5. The output of the absolute value circuit is divided by R55 and R56 to generate MUX6. The output of the reference and error amplifier circuit is divided by R46 and R47 to generate MUX7.

High Voltage Calibration *2-164.*

Refer to Figure 2-28 for the following discussion. The resistor network, (70 kΩ and 7 MΩ) which is part of the HR7 hybrid/resistor network assembly, determines the accuracy of both 1100V ac and dc ranges. Calibration involves determining its offset and gain constants.

To determine the offset, DAC outputs are connected to 70 kΩ input resistor by K1. The output of the dc HV amplifier is inverted by U1 and its output is connected to the 7 MΩ feedback resistor by K9, K8B, and K6. This configuration creates an inverting amplifier with a gain of 100. Relay K9 connects the output of this amplifier to the RCL line, where it is measured by the adc circuit on the DAC assembly (A11). The DAC's adc circuit first connects both its +input and -input to RCOM and takes a checkpoint reading. The +input is then connected to the RCL line, which at this time is the amplifier output, and adjusts the DAC output to obtain the same reading as the previous check point. This offset cal constant is stored in nonvolatile memory.

To determine the gain, the High Voltage/High Current assembly is configured in the ac 1100V range, except PA SNS DC is connected directly to the 7 MΩ input resistor of the ac sense buffer by relays K8 and K6 instead of going through step-up transformer T1. The 6.5V reference (BRF6) is connected to the Power Amplifier assembly (A16) which is configured for an inverting gain of 20 to create a -130V output. The ac sense buffer circuit attenuates this signal by 100 to generate 1.3V at its output. This 1.3V is connected to the RCL line by relay K2 where it is connected to the +input of the adc circuit on the DAC assembly. DAC OUT HI, which is connected to the -input, is adjusted until a null is achieved. The gain can be determined by using this and the previous offset reading. This determines the exact ratio of 70 kΩ and 7 MΩ resistor network on the HR7 assembly. This known ratio can then be used to output very accurate dc voltages in 1100V dc range.

Calibration of the AC Function *2-165.*

The HR7 resistor network, previously calibrated at dc, is further characterized for its frequency response. The Calibrator is placed in the ac 1100V range, except with HV OUT and HV SENSE tied by relay K11 on the High Voltage/High Current assembly (A15) instead of being tied at the load. The Oscillator Output assembly is set so the output of the High Voltage/High Current Voltage assembly is approximately 695V at 130 Hz. This high voltage output (INT HV SNS) is connected to the AC CAL line, through 399.6 kΩ resistor Z6, by relays K10 and K8A on the High Voltage assembly. The AC CAL signal is routed to the Oscillator Control assembly (A12) where it is measured by a 400Ω rms sensor.

Since the voltage is approximately 700V and it is applied through a 399.6 kΩ resistor (Z6) to the 400Ω rms sensor, approximately 1.75 mA of current flows through the rms sensor on the Oscillator Control assembly. A dc reading of the sensor, which is approximately 0.7V (1.75 mA x 400Ω), is taken and then stored in memory with the Oscillator Output level.

The Oscillator Output frequency is then increased to 500 Hz. The Oscillator Output level is adjusted so the dc reading from the rms sensor is the same as for 130 Hz, and stored in memory. This step is again repeated at 1 kHz. This characterizes the HR7 resistor network's frequency response. An accurate ac voltage can now be obtained at any frequency between 50 Hz and 1 kHz. The theory of operation for the rms sensor is contained in the Oscillator Control (A12) theory.

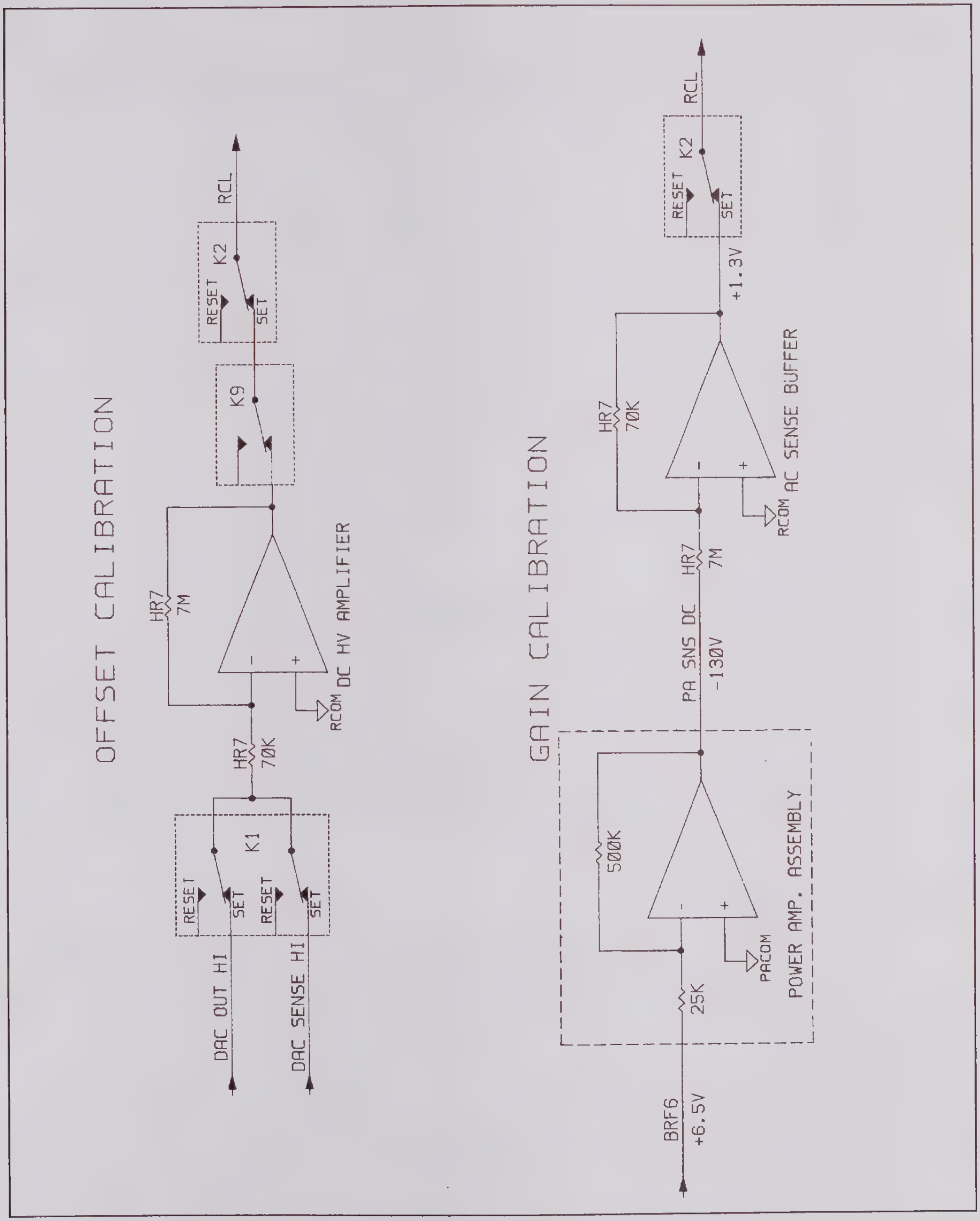


Figure 2-28. High Voltage/High Current Assembly Calibration

Calibration of the Current Function *2-166.*

Refer to Figure 2-29 for the following discussion. The resistor network Z5 determines the accuracy of the 2.2A current range. Calibration involves determining its offset and gain constants. The Calibrator is configured as in the 2.2A dc function, except that the Current assembly (A7) is set to the 2.2 mA range.

To determine offset, the output (B CUR) is routed back to the Current assembly where it is connected to INT OUT HI. INT OUT HI is routed to the Ohms Main assembly (A10), where it is connected to a previously calibrated 10Ω resistor. The voltage generated across this 10Ω resistor is routed to the differential amplifier on the Ohms Cal assembly (A9). The output of the differential amplifier is routed to the DAC assembly (A11) where it is measured by its adc circuit. A checkpoint reading is first taken by removing INT OUT HI from the 10Ω resistor and measuring the voltage across the resistor. The offset is then measured by connecting INT OUT HI to the 10Ω resistor. The DAC assembly, which controls the output of the Current assembly, is adjusted until the adc circuit measures the same as the previous checkpoint reading.

To determine gain, the Calibrator is configured as in the previous step, except with the Current assembly outputting 1.3 mA generated from the 13V reference (BRF13 and BSRF13) from the DAC assembly. This 1.3 mA is amplified 100 times by the 2.2A amplifier. The resulting 130 mA is connected to the 10Ω resistor on the Ohms Main assembly by the same path as for the offset calibration. The resulting 1.3V across this 10Ω resistor is routed to the Ohms Cal assembly (A9), where it is connected to the -input of the differential amplifier. The +input of the differential amplifier is connected to the output of the DAC assembly. The output of the differential amplifier is connected to the RCL line which is routed to the adc circuit on the DAC assembly. The DAC output, which is the +input of the differential amplifier, is adjusted until a null is measured on the RCL line by the DAC's adc circuit. This step is repeated by changing the -input of the differential amplifier to the other side of the 10Ω resistor. The software now computes the exact voltage drop across the 10Ω resistor. Gain is determined by using this and the previous offset reading.

High Voltage Magnitude Control *2-167.*

The square wave (HVCL) used in the previously described functions, is created and amplitude controlled by the High Voltage Control assembly (A14). This circuitry, shown on sheet 2 of the schematic, contains the absolute value circuit, signal/polarity selection circuit, reference and error amplifier, square wave generator, and the square wave amplifier.

The absolute value circuit contains op amp U2A, U2B, Q3, diodes CR8 and CR9, capacitor C20, and resistors R27-R32 and R68. During operation in the ac current function, this circuit creates an absolute value of the G OUT signal from the collectors of the 2.2A output transistors. Op amp U2A generates a negative half-wave signal equal to the positive peaks of G OUT. Resistors R32 and R27 sum this half-wave signal and the input signal G OUT at the input of U2B. Capacitor C20 averages the voltage so the output of U2B is a dc voltage which represents the positive peak voltage of G OUT. In the high voltage dc function, the 2.2A amplifier circuit is not used, so the output of U2B is 0V.

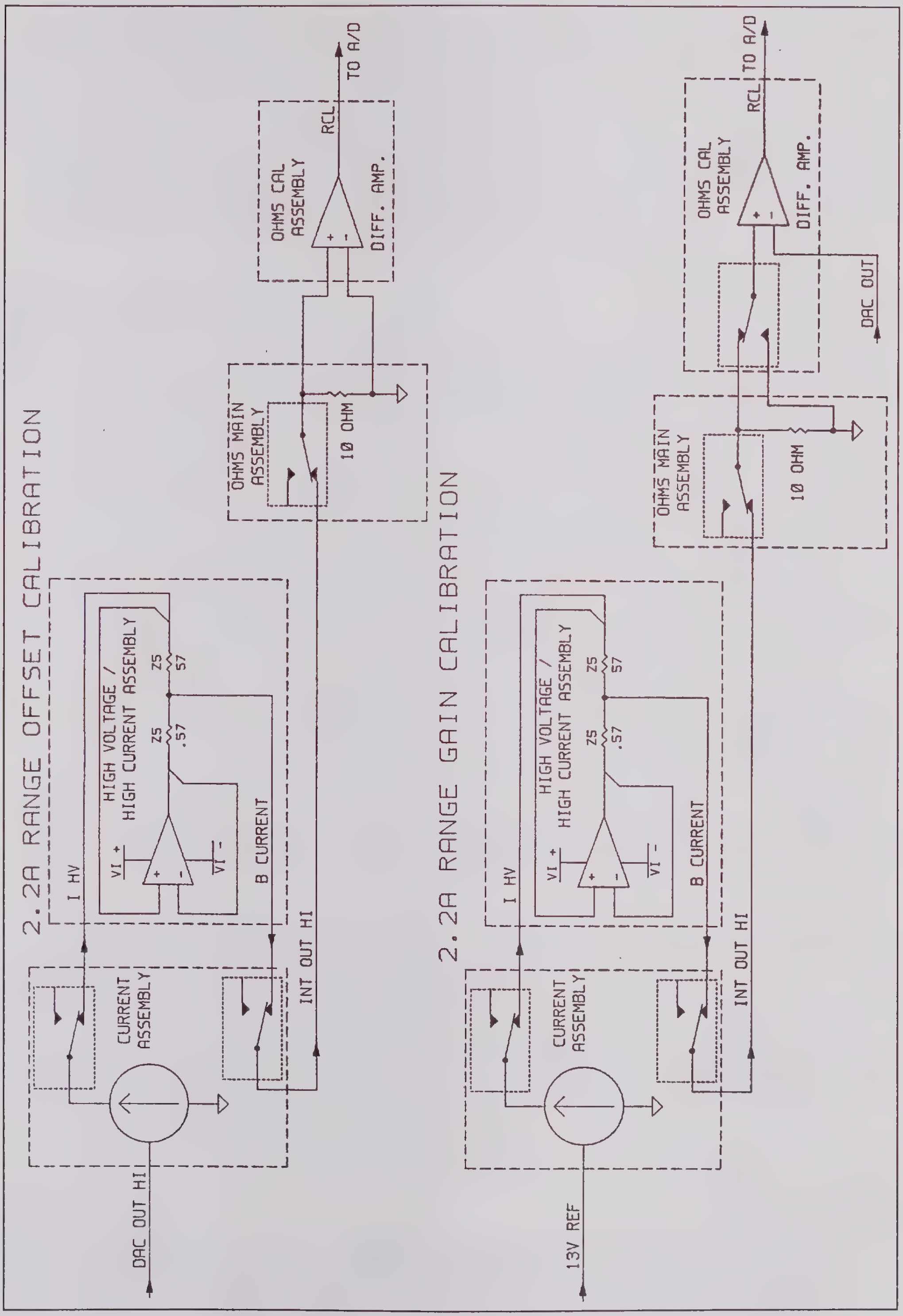


Figure 2-29. High Voltage/High Current Assembly 2.2A Range Calibration

The signal/polarity selection circuit generates the ERROR SIGNAL used by the error amplifier. It contains op amp U2C, CMOS analog switch U6, and resistor R35-R39. Control line V/I controls U6B and U6C which select the VI± when in the current mode. Control lines ±* and ± control U6A and U6D respectively. These switches, operating in conjunction with U6B and U6C, select between VI±, -SP C or +SP C. In the current function, U2C subtracts the power supply voltage (VI±) from the absolute voltage created by the absolute value circuit to create ERROR SIGNAL. This gives a measure of the emitter to collector voltage of the driving device for each operating function. In the positive dc voltage function, U2C is configured as a unity-gain inverting op amp. In the negative dc voltage function, U2C is configured as a voltage follower.

The reference and error amplifier circuit contains op amp U2D, CMOS analog switch U7B, zener diode VR1, transistors Q2 and Q4, diodes CR10-CR11, capacitor C18, and resistors R40-R45. Zener diode VR1, R40-R45, Q4, and U7B create a reference voltage. Control line V/I controls U7B which switches R43-R45 in or out to change this reference voltage value, depending on the operating function. In the HV dc range, R40 and R41 are used, balancing the error amplifier with the ERROR SIGNAL near 6.8V. In the 2A dc range, U7B and Q4 are on, R43 is paralleled with R41, and R45 is paralleled with R40, so the error amplifier balances when the ERROR SIGNAL is near 3.1V. In the 2A ac function, Q4 is off, R44 is in series with R45, so the error amplifier balances when the ERROR SIGNAL is about 5.2V. The output of U2C, ERROR SIGNAL, is summed with the reference voltage by R40 and R41. This voltage is connected to the error amplifier U2D which, with C18, is configured as an integrator. The error amplifier generates the signal AMPLITUDE, which dynamically controls the amplitude of the square wave. This AMPLITUDE is connected to the input of U7C. -AMPLITUDE, provided by inverting op amp U1A, is connected to the input of U7D. Control line PS OFF provides a soft start of the error amplifier. With this line high, Q2 is turned on, shorting C18, which sets the AMPLITUDE control line to 0V. Once the High Voltage/High Current assembly is set up for proper operation, this line goes low to turn off Q2.

The square wave generator circuit creates a 1 kHz signal QSQB and its complement QSQB*. These signals are generated by R26, C17, and a stable multivibrator U4. Control line FREQ controls the CMOS analog switch U7A, which parallels R25 to R26. This changes the frequency of oscillation to prevent beating when putting out 2A ac near 1 kHz. Control line PS OFF goes high to shut down this oscillator when its not required.

The square-wave amplifier contains op amp U3 and CMOS analog switches U7C and U7D. Switch U5C is connected to the AMPLITUDE voltage and is controlled by QSQB from the square wave generator. Switch U7D is connected to AMPLITUDE through inverting op amp U1A and is controlled by QSQB* from the square wave generator. The input signal to the square wave amplifier is the output of U7C and U7D. Since QSQB* is the complement of QSQB, the resulting square wave has a positive peak equal to AMPLITUDE, and a negative peak equal to -AMPLITUDE. This square wave is amplified by U3, which is configured for a gain of 2.6, to create HVCL. HVCL is the square-wave signal used by the Power Amplifier assembly in the previously described functions.

Ohms Overview 2-168.

The Ohms function for the Calibrator is provided by two plug in circuit boards, the Ohms Main assembly (A10) and the Ohms Cal assembly (A9). These two assemblies function as one to supply fixed values of resistance from 1Ω to 100 MΩ. Resistance output is available in values of 1×10^n (1, 10, 100, 1k ... 100M) and 1.9×10^n (1.9, 19, 190, ... 19M) from short to 100 MΩ. After the ohms function is calibrated, the Output Display shows the true value of the resistance selected.

These assemblies are also used to calibrate the Calibrator Current function. The Ohms Main assembly contains all the resistor values except the 1Ω, 1.9Ω, and short, which are located on the Ohms Cal assembly. It also contains the relays and their drivers to switch these values as requested under program control.

The Ohms Cal assembly contains all calibration circuits except for one op amp on the Ohms Main assembly. It also contains a circuit to provide accurate calibration of two-wire ohmmeters. In addition, there are relays, relay drivers, and logic to interface the Ohms assemblies to the digital bus. Refer to Figure 2-30 for a simplified schematic of both the Ohms Main and Ohms Cal assemblies.

Ohms Main Assembly (A10) ***2-169.***

The Ohms Main assembly uses three Fluke hermetically-sealed thin film resistor networks (Z1, Z2 and Z3) to obtain values from 10Ω to 19 MΩ. The values are arranged in two strings, one for decade values and the other for the multiples of 1.9. The 100 MΩ value is achieved by inserting a 90 MΩ film resistor (R1) in series with the decade string.

Selection of Resistance Values *2-170.*

Refer to Figure 2-31 for the following discussion. Relays select the resistance values. All resistor values have four-wire connections except 100 MΩ, which is two-wire. The output high and sense high side of a resistance value is connected to INT OUT HI and INT SENSE HI by relays K1 and K2 in the reset position, except 100 MΩ, which is connected to INT OUT HI by K5. Relays on the motherboard connect INT OUT HI and INT SENSE HI to the OUTPUT HI and SENSE HI binding posts.

The low side of the 1x string is connected to OHMS SENSE LO and OHMS OUT LO by relay K27 (A and B) in the reset position. The low side of the 1.9x string is connected to the same lines by relay K39 (A and B). These lines are routed to the Ohms Cal assembly where they are connected via relays to the OUTPUT LO and SENSE LO binding posts.

The 10 MΩ value is selected by K7 (reset) and K8 (energized) and the 1 MΩ value by K9 and K10 (reset). Selection of decades below 1 MΩ is done by K15 and K16 (reset) plus a pair of relays from K17 through K26A. For example, to select 10 kΩ, relays K18A and K20A are reset.

The 19 MΩ value is selected by K11 and K12 (energized), and the 1.9 MΩ value by K13 and K14 (reset). Selection of 1.9 decades below 1.9 MΩ is done by K35 and K36 (reset) plus a pair of relays from K18B through K26B and K37.

Two lines, OHMS OUT HI and OHMS SENSE HI, are brought over to the Ohms Cal assembly to connect to 1Ω, 1.9Ω, and short. These lines also access resistance values during calibration. Relay K29 connects OHMS OUT HI to the $1x10^n$ string when set, and to the $1.9x10^n$ string when reset. Relay K30 connects OHMS SENSE HI to the $1.9x10^n$ string during calibration.

Relays K3, K28, K31-K34, and op amp U1 and its associated components are only used during calibration. Operation of this circuitry is described in the "Calibration" part of the Ohms Cal theory.

Relays K4 and K6 are used during two-wire compensation. This is described in the "Two-Wire Compensation" part of the Ohms Cal theory.

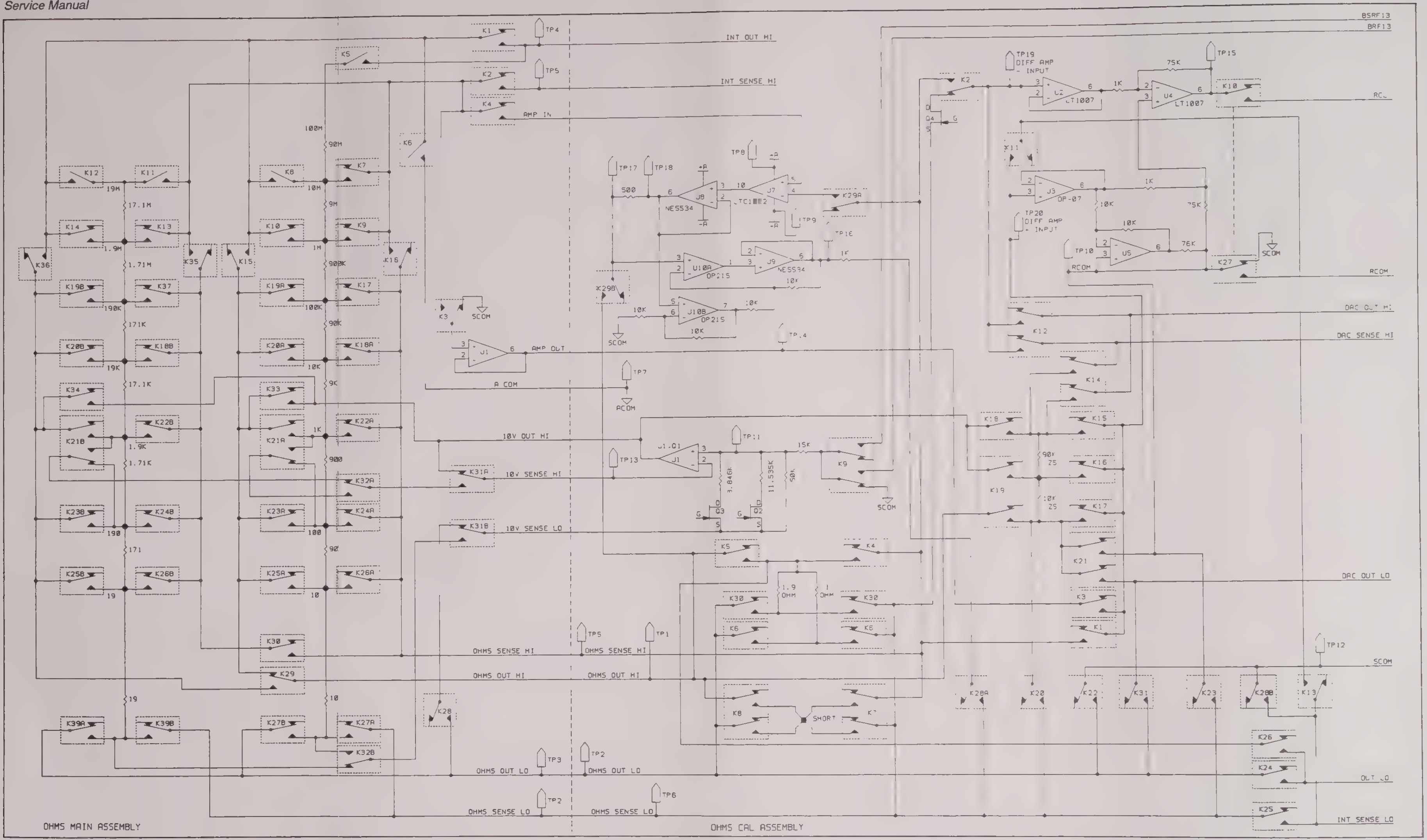


Figure 2-30. Ohms Assemblies Simplified Schematic

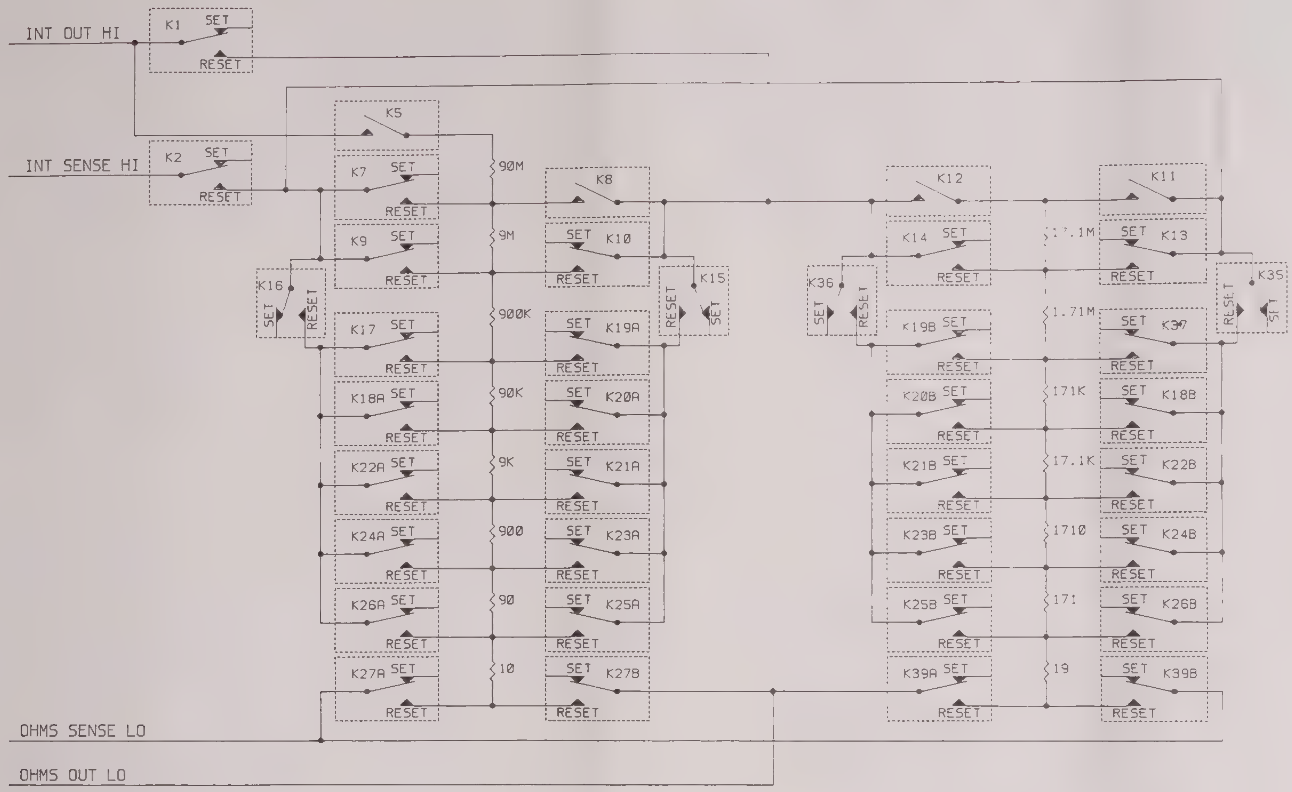


Figure 2-31. Ohms Main Assembly Simplified Schematic

Ohms Main Assembly Support of Current Function Calibration 2-171.

To calibrate the current function, the Current assembly routes output current to the Ohms Main assembly, where it is connected through a resistance. Current is determined by measuring the voltage across this resistance. During calibration, half of K38 connects DAC OUT LO to the SENSE LO side of the 1×10^n string (Z1 pin 6). The Current assembly generates approximately 60 µA of current on the DAC OUT LO line, which can cause an error during measurement. To prevent this error, half of relay K38 connects the -17S supply through R6 to the DAC OUT LO line. This generates an opposite-polarity 60 µA current to cancel the current from the Current assembly.

Ohms Digital Control 2-172.

The Ohms Main assembly is digitally controlled by the 82C55 Programmable Peripheral Interface IC on the Ohms Cal assembly. This IC, under system software control through the guarded digital bus, has three ports generating 24 outputs. PA0-PA7 of port A, PB0-PB3 of port B, and PC0-PC4 of port C are routed on the motherboard to the Ohms Main assembly. These lines and two decoders in U9 and U10 control nine relay driver ICs, which in turn control 39 Ohms relays. Relay driver U3 drives non-latching relays K5, K6, K8, K11, K12 and K38. Relay drivers U2, U5-U8, and U11-U13 drive the latching relays.

Port A (PA0-PA7) is a common input bus for all relay drivers. IC U9 decodes PB0-PB3 to strobe the latching relay drivers. This signal causes the contents of the data on the input bus to be latched into the latch portion of the selected device. IC U10 decodes PC0-PC3 to provide four enable lines. Each line goes to two latch/drivers and when true (0V), drives the relay coils on or off according to the contents of the latch. Since these are latching relays, they are pulsed only briefly. The latching relays each have two coils, one to set the relay and one to reset it. When the ohms function is not being used, all relays are set, as shown on the schematic.

PC4 is the strobe line for non-latching relay driver U3. The enable is connected to LH COM so the relays receive constant drive. These non-latching reed relays are shown in the non-energized state.

Ohms Cal Assembly (A9) 2-173.

The Ohms Cal assembly (A9) contains the 1Ω, 1.9Ω, and short resistance values. It also contains a digital control circuit, and a two-wire compensation circuit to allow accurate calibration of two-wire ohmmeters. A differential amplifier circuit and a 2/5/10V source circuit are used during calibration of the ohms function.

Ohms CAL Digital Control 2-174.

The heart of the Ohms Cal assembly digital control circuit is the 82C55 Programmable Peripheral Interface IC (U11) mentioned previously under "Digital Control". This IC has three ports generating 24 outputs. These outputs control seven 5801 latching relay drivers ICs (U14-U20), a 4051 analog multiplexer (U21) for self diagnostics, and several FET switches.

Port A (PA0-PA7) is a common input bus for latching relay drivers and multiplexer U21. These lines also go to the Ohms Main assembly as previously described to control relay drivers there.

Lines PB0-PB3 of port B goes to decoder U12 (PB3 is inverted by U22) and to the Ohms Main assembly. The output of U12 strobes latch/driver ICs to latch data on input bus lines.

Lines PC0-PC3 of port C go to decoder U13 and to the Ohms Main assembly. Decoder U13 enables two latch/driver ICs at a time. Setting the enable true (0V) causes the relay coils to be driven on or off depending on the contents of the latch portion of the selected ICs. Since these are latching relays, they are pulsed only briefly.

The outputs PB4, PB5 and PB6 of U11 are connected to the gates of FETs Q2, Q3 and Q4 respectively. The Programmable Peripheral Interface IC turns them on for a one (5V) and off for a zero (0V). PB7 is connected to the base of Q6 through R31. When PB7 is true (5V), it turns on Q6, which turns on Q5, which in turn supplies +17S to U6. PC4 goes to the Ohms Main assembly where it strobes relay latch/drivers for the non-latching relays.

Line PC6 goes to the diagnostic circuit where it enables and disables output from the multiplexer (U21). Connected to the input of the multiplexer are five voltage dividers made from resistors in Z3 and Z4.

Two inputs to these dividers are connected. One is 10V OUT HI from the 2/5/10V source circuit. The other is 2W COMP from the two-wire compensation circuit. These inputs are connected to the SDL line by the multiplexer, where they are routed to the adc circuit on the DAC assembly and measured during calibrator diagnostics. PC7 is not used.

1, 1.9, and Short Resistance — *2-175.*

Although located on the Ohms Cal assembly, the 1Ω value, 1.9Ω value, and short operate as part of the Ohms Main assembly, filling out the range of values available to the operator. The 1Ω value is made of four 4Ω wirewound resistors in parallel (R41). The 1.9Ω value is made of two 3.8 ohm wirewound resistors in parallel (R42). Relays K4 and K5 connect the 1 ohm and 1.9Ω values to OHMS OUT HI and OHMS SENSE HI. Relays K6 and K30 connect them to OHMS OUT LO and OHMS SENSE LO. Relays K7 and K8 select the short.

The Ohms Cal assembly contains the relays that switch the low side of the selected resistance onto the output bus. (High sides are connected to the output bus by relays on the Ohms Main assembly.) Relay K24 connects OHMS OUT LO to OUT LO and K25 connects OHMS SENSE LO to INT SENSE LO.

Two-Wire Ohmmeter Compensation Circuit — *2-176.*

Refer to Figure 2-32 for the following discussion. The Ohms Cal assembly contains a two-wire lead drop compensation circuit that allows accurate calibration of two-wire ohmmeters. The error normally encountered when calibrating a two-wire ohmmeter is due to the voltage drop in the path resistance between the meter and the calibration resistor. This circuit reduces the voltage drop to an insignificant level. Two wire compensation can be used only with ohm meters that source continuous (not pulsed) dc current.

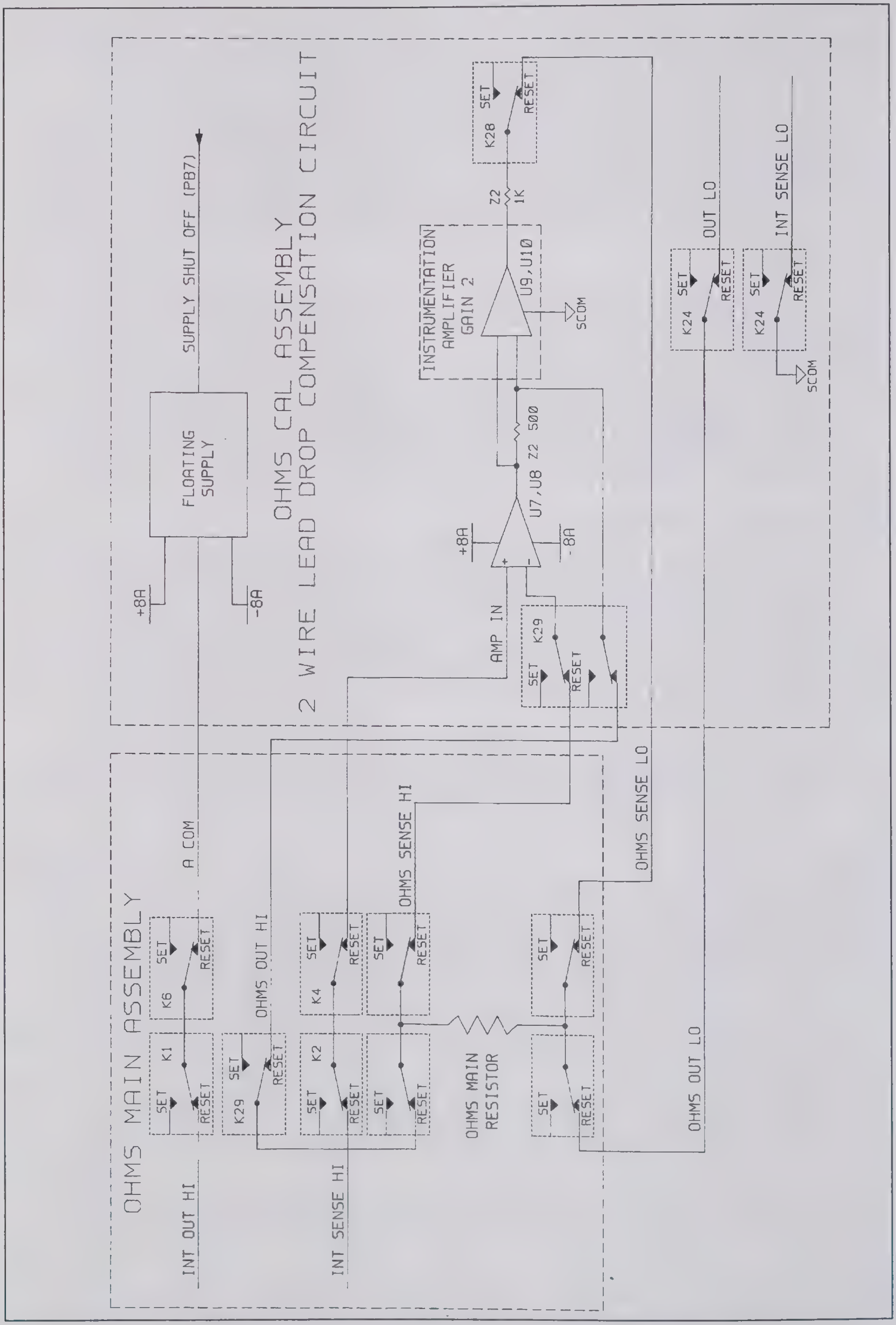


Figure 2-32. Two-Wire Lead Drop Compensation Circuit

Two-Wire Compensation Power Supplies 2-177.

The floating supplies for U7 and U8 consist of a dc-to-dc converter made up of U6, T1 and associated components. Switching-regulator control IC U6 switches +17S through the primary of T1 at about 30 kHz as determined by R27 and C21. The switching creates high-frequency spikes on the +17S line which are filtered out by L2, R25, C18, C19, C20, and C52. When the two-wire compensation circuit is not in use, control line PB7 turns Q5 and Q6 off, which removes +17S, switching off U6. The secondary of T1 is rectified and filtered by CR1, CR2, CR9, CR10, C22, and C23. The voltage is then regulated by 8.2V zener diodes VR1 and VR2. Additional filtering is provided by L3, L4, R43, R44, C24, and C25. Two capacitors (C53 and C54) between A COM and S COM reduce switching noise that would otherwise appear across the calibration resistor.

High Side Cancellation 2-178.

The high side voltage drop is eliminated by U7 and U8. Chopper-stabilized op amp U7 and buffer amplifier U8 supply up to 10 mA. The current from the high side of the ohmmeter being calibrated enters at the OUTPUT HI binding post, goes through K1 and K6 on the Ohms assembly, and is routed to the Ohms Cal assembly where it connects to A COM. The A COM connection is a common for the floating supply that powers U7 and U8. The current then flows out of U8 through 500Ω in Z2 and through K29 to the calibration resistor via the OHMS OUT HI line.

K29 connects the -input of U7 to the sense point of the calibration resistance via OHMS SENSE HI. Relays K2 and K4 on the Ohms Main assembly connect the +input of U7, AMP IN, to INT SENSE HI. Relays on the motherboard connect INT SENSE HI to the OUTPUT HI or SENSE HI binding post. Connected this way, U7 controls the voltage at the output of U8 so that the voltage at the input of U7 stays zero. This forces the voltage drop in the path to zero. Diodes CR3-CR6 and resistor R45 provide protection for U7.

Low Side Cancellation 2-179.

The voltage drop in the low side path is canceled by current from high current op amp U9. U9 is driven by dual FET input op amp U10. The two non-inverting inputs of U10 are connected across the 500Ω resistor in Z2. This enables U10, in conjunction with the four 10 kΩ resistors in Z2, to sense the current in the high side path and to supply (through U9 and the 1 kΩ resistor in Z2) a current equal but opposite to the current through the low side path. This cancels the drop in that path. This canceling current goes through relay K28A to the low sense point of the calibration resistor via OHMS SENSE LO. From there it goes through the output low path to the OUTPUT LO binding post and then through the sense low path back to the Ohms Cal assembly and through K28B to S COM.

Ohms Calibration *2-180.*

The remaining circuitry is used only for calibration of the resistor values. All values except 1Ω and 1.9Ω are calibrated using a single external 10 kΩ resistance standard connected to the binding posts. The 1Ω and 1.9Ω values are calibrated using an external 1Ω standard. How to do the procedure is described in Section 7 of the Operator Manual.

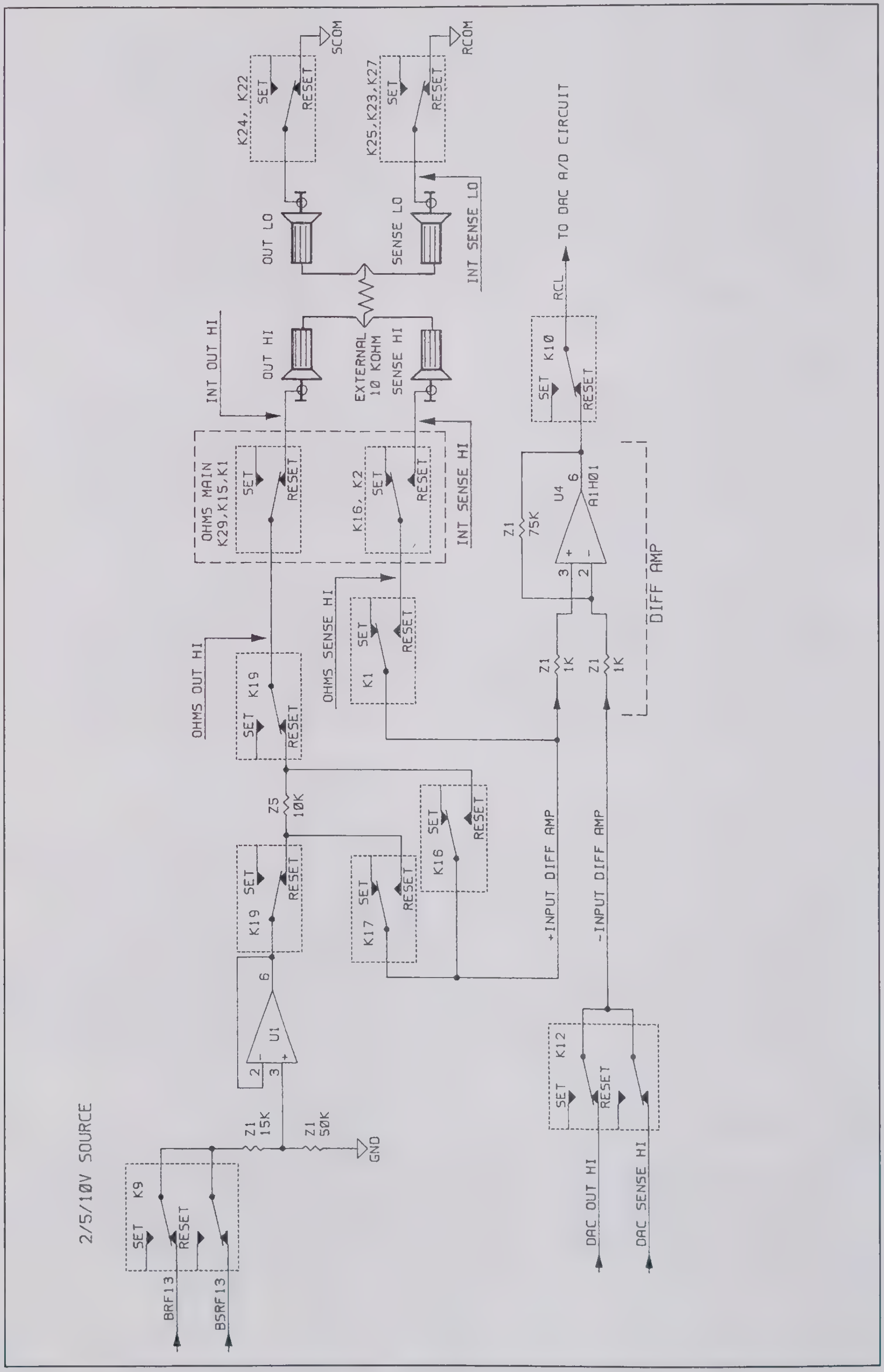


Figure 2-33. Calibration to an External 10 kΩ Standard

Calibrating to the External 10 KW Standard 2-181.

Refer to Figure 2-33 for the following discussion. The first step in ohms calibration is to compare the 10 kΩ standard against the 10 kΩ value on the Ohms Cal assembly. This is done by passing a current through both values and measuring the voltage drop across each. The ratio of the voltages is equal to the ratio of the resistances.

The source of current comes from the 2/5/10V source circuit, which contains U1, Q1, Q2, Q3 and Z1. The buffered 13V reference voltage from the DAC assembly (A11) is switched through K9 to a voltage divider made up of resistors in Z1.

To calibrate the 10 kΩ resistance, control lines PB4 and PB5 turn off FETs Q2 and Q3 respectively. In this mode, the output of the divider uses the 15 kΩ and 50 kΩ values to produce an output of 10V. This voltage is buffered by U1 and Q1. The current from this source, 10V OUT HI, is sent through K19 to one side of the 10 kΩ resistance in Z5. 10V SENSE HI is connected to 10V OUT HI by K31A on the Ohms assembly. The other side of the 10 kΩ resistance in Z5 is connected to OHMS OUT HI by K19. This is routed to the Ohms Main assembly where is goes through K29, K15 and K1 to INT OUT HI, which is connected to the OUTPUT HI binding post by relays on the motherboard. From there it goes through the external 10 kΩ standard and back in through the OUTPUT LO binding post and over to the Ohms Cal assembly where it connects to S COM through K24 and K22.

The voltage drops are measured by comparing each voltage to the DAC assembly output in a differential amplifier circuit made of U2 through U5.

Since the DAC and differential amplifier are referenced to R COM, this line is brought out through K27, K23 and K25 to INT SENSE LO. This is connected to the SENSE LO binding post (which is connected to the sense low point of the standard). Line DAC OUT LO is tied to S COM by relay K31. The high side of the DAC, DAC OUT HI and DAC SENSE HI, are tied together and connected by K12 to U2, which is the differential amplifier -input.

The voltage to be measured is connected to U3, which is the differential amplifier +input. The output of U2 and U3 goes to U4 through gain setting resistors in Z1. These set the gain of the differential amplifier to 75. The differential amplifier generates a current through the 1 kΩ (pins 1-2) and 75 kΩ (pins 2-3) resistors in Z1 to R COM. This current on R COM can cause an error during measurement. Op amp U5, configured as an inverting amplifier, generates an equal current of opposite polarity through 76 kΩ resistor R18 to cancel the current from the differential amplifier. The output of U4 goes through K10 to the RCL line. This line is connected to the DAC assembly, where it goes through an amplifier to the adc circuit.

The calibration program uses the adc circuit to measure the differential amplifier output voltage. First the differential amplifier offset voltage is determined. (This offset is different for each input condition.) Readings are taken to determine each offset voltage by checking the output of the differential amplifier at equal voltages on the inputs. This is done by switching K11 to the reset position to connect the differential amplifier +input and -input together, then measuring the output with the DAC's adc circuit.

Once the offsets are known, the software determines the calibration voltages by adjusting the DAC output until the adc reading is the same as the offset. At that point, the DAC output equals the voltage being measured.

Three readings are required to determine the ratio of the two resistances. For the first reading, K16 connects the differential amplifier +input to the 10 kΩ resistor in Z5. For the second reading, K17 connects the +input to the other side of that resistor. Subtracting the first reading from the second gives the voltage across the internal 10 kΩ. For the third reading, K1 on the Ohms Cal assembly connects the + input to OHMS SENSE HI.

OHMS SENSE HI is connected to INT SENSE HI by K16 and K2 on the Ohms Main assembly. INT SENSE HI is connected to the SENSE HI binding post by relay K2 on the motherboard which is the sense high side of the 10 kΩ external standard. The ratio of this third reading to the difference of the first two readings is proportional to the ratio of the two resistances. Thus by knowing the resistance of the external standard, the software can calculate the value of the internal 10 kΩ resistance value.

Calibrating 10 KW and 19 KW 2-182.

The next step in calibrating the ohms function is to determine the 10 kΩ and 19 kΩ values on the Ohms Main assembly. This is done just like the 10 kΩ value on the Ohms Cal assembly, except the 10 kΩ resistance on the Ohms Cal assembly acts as the standard and is placed in series with 10 kΩ or 19 kΩ on the Ohms assembly.

This is done using K19 on the Ohms Cal assembly and K29, K20A and K27 on the Ohms Main assembly for the 10 kΩ, and K29, K20B and K39 for the 19 kΩ value. The source on the Ohms Cal assembly again outputs 10V. Again three readings are taken. The first and second are the same as previously described. For the third reading, the differential amplifier +input is connected through K1 on the Ohms Cal assembly and through K18A on the Ohms Main assembly for 10 kΩ and K30 and K18B for 19 kΩ. The software then calculates the 10 kΩ and 19 kΩ values using the ratio of readings and the known value of the 10 kΩ on the Ohms Cal assembly.

Calibrating 100 KW 2-183.

Once the 10 kΩ value is determined, the 100 kΩ value is calibrated by comparing its value against 10 kΩ. The 10V source is connected across 100 kΩ. Since the 10 kΩ resistance is used as part of 100 kΩ, the current goes through both.

Relays K33 and K19A on the Ohms Main assembly connect 10V OUT HI to 100 kΩ. Relays K23 and K27 on the Ohms Cal assembly connects OHMS SENSE LO to RCOM. OHMS OUT LO, DAC OUT LO, and 10V SENSE LO are connected to SCOM. Relay K22 on the Ohms Cal assembly connects OHMS OUT LO to SCOM. OHMS OUT LO is connected to DAC OUT LO by K31 on the Ohms Cal assembly, and to 10V SENSE LO by K31B and K28 on the Ohms Main assembly.

Only two readings are required because this time there is no path resistance to subtract out. DAC OUT HI and DAC SENSE HI are tied together and connected to the -input of the differential amplifier by relay K12.

For the first reading, the +input of the differential amplifier is connected to the sense side of the 100 kΩ point in the string through K1 on the Ohms Cal assembly and K17 on the Ohms Main assembly. For the second reading, the + it is connected to the 10 kΩ point by K18A. The software calculates the 100 kΩ value from the ratio of the readings and the known 10 kΩ value.

Completion of High Resistance Value Calibration 2-184.

Once 100 kΩ is determined, 1 MΩ and the other values up to 100 MΩ are determined in a similar way. Using the same techniques, 190 kΩ is calibrated against 19 kΩ, and so forth up to 19 MΩ.

Too much current noise is generated by U3 in the differential amplifier circuit for accurate calibration of resistances above 1 MΩ. For these values, U1 on the Ohms Main assembly (a low-bias current FET op amp) is switched ahead of U3.

The 1 kΩ and 1.9 kΩ resistance values are determined from the 10 kΩ and 19 kΩ respectively.

The 10Ω, 19Ω, 100Ω and 190Ω resistance values are determined using 2V from the 2/5/10V source and using internal 10:1 divider (Z5) in conjunction with the DAC. To get 2V, Q2 and Q3 are both turned on, which parallels both the 11.535 kΩ value and the 3.846 kΩ value with the 50 kΩ value. The lower voltage is required to lower the power dissipation in the resistors.

Using 2V presents a problem for the DAC. Instead of working at 10V and 1V, it would be working at 2V and 0.2V. This level is too low to get accurate results from the DAC. To solve this problem, the DAC is used only at 2V and the 0.2V level is achieved using a 10:1 divider. The DAC calibrates this 10:1 divider at 10V and 1V. The divider is made of a 90 kΩ and a 10 kΩ resistor in Z5. To calibrate the divider, 10V is applied to the top of the divider through K18. The low side of the divider is connected to R COM (K21 and K27), DAC OUT LO (K21) and S COM through K20 on the Ohms Cal assembly, K27A/B on the Ohms Main assembly and K22 on the Ohms Cal assembly. Two readings are taken. Their ratio is equal to the division ratio of the divider. The -input of the differential amplifier is connected to the DAC output by K12. For the first reading, K15 connects the top of the divider to the +input of the differential amplifier. For the second reading, K16 connects the divider point to the +input of the differential amplifier. The exact ratio of this divider can now be determined by these two readings.

Refer to Figure 2-34 for the following discussion. To calibrate the 10Ω resistor, the DAC output is connected to the top of the divider by K14. The 2V source is connected across 100Ω on the Ohms Main assembly. This is done by 10V OUT HI, set to 2V, connected to the high side of the 100Ω string by K33 and K23A on the Ohms Main assembly. Line 10V SENSE HI is also connected to this point by K31A and K32A on the Ohms assembly. Line OHMS OUT LO and OHMS SENSE LO are connected to the low side of the 100Ω string by K27B and K27A respectively. Line OHMS OUT LO is connected to SCOM by K22 on the Ohms Cal assembly and is also connected to 10V SENSE LO by K32B and K31B on the Ohms Main assembly. OHMS SENSE LO is connected to the low side of the internal divider by K20 on the Ohms Cal assembly. The Ohms Cal assembly also connects RCOM to the low side of the divider by K27 and K21. Relay K21 also connects this point to DAC OUT LO.

Two measurements are taken. The first is with the +input of the differential amplifier connected to the DAC output through K15. The - input is connected to the sense point of the 100Ω resistance by K24A on the Ohms Main assembly and K2 on the Ohms Cal assembly. The DAC is adjusted until its value is the same as the voltage across 100Ω. Then the inputs of the differential amplifier are moved. The +input is connected to the divider output on the Ohms Cal assembly by K16. The - input is connected to the sense point of the 10Ω resistance by K26A on the Ohms Main assembly and K2 on the Ohms Cal assembly. The DAC is again adjusted until the voltages are equal. The differential amplifier sees 0.2V on each input for this measurement but the DAC is at 2V. The value of 10Ω is determined from the two DAC settings and the division ratio of the divider on the Ohms Cal assembly. The same procedure is used to determine the 100Ω value from the 1 kΩ value, the 190Ω value from the 1.9 kΩ value and the 19Ω value from the 190Ω value.

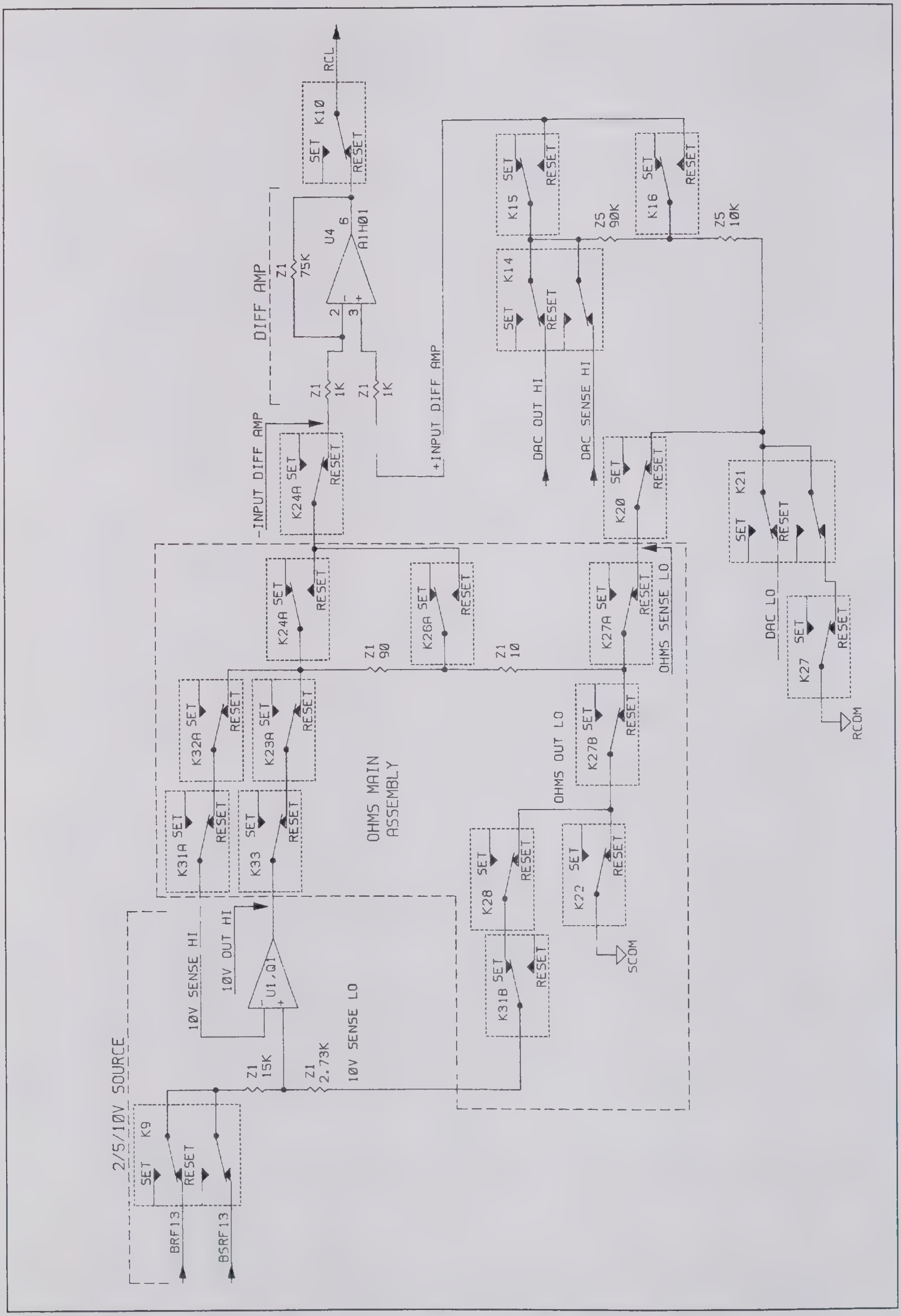


Figure 2-34. Ratio Calibration, 10Ω From 100Ω

Calibrating to the External 1W Standard 2-185.

The 1Ω and 1.9Ω resistor values are calibrated by comparing them against a 1Ω external standard. The technique used is different from that used for the 10 kΩ external standard.

The Current assembly supplies a 130 mA (65 mA for 1.9Ω calibration) current through both resistors. This current goes out the OUTPUT HI binding post to the 1Ω standard. It comes back in through the OUTPUT LO binding post and through the internal 1Ω resistance by K26 and K6, or 1.9Ω by K26 and K30 before going to S COM through K22.

For the first reading, the inputs to the differential amplifier are connected across the sense points of the 1Ω standard. Relay K1 connects the differential amplifier +input to OHMS SENSE HI, which is connected to INT SENSE HI by K16 and K2 on the Ohms Main assembly. INT SENSE HI is connected to the SENSE HI binding post by relays on the motherboard. Relay K13 connects the differential amplifier -input to INT SENSE LO which is connected to SENSE LO binding post by relays on the Switch Matrix assembly.

The voltage between the inputs is 0.13V, which is amplified by 75 by the differential amplifier to approximately 9.75V and sent to the DAC assembly on the RCL line. Another differential amplifier on the DAC assembly compares the 9.75V to the DAC output. Before the reading is taken, however, amplifier offsets are determined.

When the DAC output equals the output of the differential amplifier on the Ohms Cal assembly, the reading is stored and a second reading is taken. For this reading, the inputs to the differential amplifier on the Ohms Cal assembly are connected across the 1Ω or 1.9Ω on the Ohms Cal assembly. The +input of the differential amplifier is connect through K1 and K4 and the -input is connected through K2 and FET Q4. The second reading is taken the same way as the first. The ratio of the two DAC settings are equal to the ratio of the values of the two resistors. The value of the 1Ω and 1.9 ohm resistors are determined from this ratio and the value of the external standard.

Current/High Resolution Oscillator Assembly Overview (A7) 2-186.

The Current/Hi-Res (High-Resolution Oscillator) Assembly combines two functions on one circuit board. The Current section generates dc and ac currents in the range of 20 μA to 220 mA. The Hi-Res section generates a high-resolution signal accurate in frequency to 4 1/2 digits, which is used by the phase-locked loop circuit on the Oscillator Output assembly (A13). These two functions are independent circuits except for the sharing of some digital controlling and self-diagnostic monitoring. The following theory describes the digital control circuitry used by both circuits, then independently covers the Current and Hi-Res functions.

The heart of the Current/Hi-Res assembly digital control circuitry is a 82C55 Programmable Peripheral Interface IC (U7), which is under software control via the guarded digital bus. This IC has three ports which generate 24 outputs. These outputs control three UCN5801 latching relay drivers ICs (U8-U10), a UCN5800 relay driver (U11) for controlling non-latching relays, a 4051 analog multiplexer (U12) for self diagnostics, and several FET switches throughout the assembly. Port A (PA0-PA7) is a common input bus called CONTROL BUS on the schematic. This CONTROL BUS transmits the desired state of all the relays (K1-K17) in the Current section, and also to control two synthesizer ICs (U16, U17) in the Hi-Res section.

Four relay driver ICs drive latching controlling relays K1-K13 and K16. The CONTROL BUS (port A of U7) is a common input bus. Port C of U7 (PC0-PC5) provides the strobe and enable lines for these relay drivers. PC0 enables U8, while PC1 enables U9 and U10. PC2, PC3, PC4, and PC5 strobe U11, U8, U9, and U10 respectively.

Relay driver U11 controls the three non-latching relays K14, K15, and K17 on this assembly. It also generates control line RLY11* to control K11 on the Motherboard. Relay K11 routes I-GUARD, described later, to the rear panel for operation when the rear-panel binding posts are in use.

The diagnostic circuit allows the calibrator to monitor five points on the assembly. Points DUMMY LOAD, OVEN TEMP, and CUR/COMP MONITOR are from the Current section. Points HI-RES LOOP and HI-RES CLOCK come from the Hi-Res section. Outputs PB0-PB2 select which point the multiplexer U12 monitors. PC6 enables the output of U12 to the SDL line, where it is measured by the adc circuit on the DAC assembly (A11).

Outputs PB3-PB5 generate control lines FET3, FET1, and FET2 respectively, which are used by the Current section. FET1 controls NMOSFETs Q21 and Q22, FET2 controls Q20 and Q23, and FET3 controls quad CMOS analog switches U5A, U5C, and U5D. Output PB7 generates control line FET4, which controls analog switch U5B.

Outputs PB6 and PC7 generate control lines HI-RES RANGE and HI-RES ON/OFF respectively, which are used by the Hi-Res section. These lines control quad CMOS analog switch U18 and comparator U13.

Current Section *2-187.*

The current section of the A7 assembly uses dc voltage from the DAC assembly and ac voltage from the Oscillator Output assembly to generate both ac and dc current outputs. Four ranges of output current each for ac and dc are generated as shown in Table 2-14. AC current is available from 40 Hz to 10 kHz.

Table 2-14. AC and DC Current Ranges

Range	DC Current Limits	AC Current Limits
220 μA	0 to 219.9999 μA	9.000 μA to 219.999 μA
2.2 mA	0.220000 mA to 2.199999 mA	0.22000 mA to 2.19999 mA
22 mA	2.20000 mA to 21.99999 mA	2.2000 mA to 21.9999 mA
220 mA	22.0000 mA to 219.9999 mA	22.000 mA to 219.999 mA

The 2.2A range is generated on the High Voltage/High Current assembly (A15) and routed to this assembly for switching to the OUTPUT binding posts. This is further described under the heading, "2.2A Range."

The transconductance amplifier, shunt resistors, feedback loop, and complementary drive circuits form a loop to create the output current. In addition to these circuits, the Current assembly contains input switching, output switching, a current guard, and a current/compliance voltage monitor. Each of these circuits is described in detail. To better understand the theory of operation, refer to Figure 2-35 and the schematic.

Current Input Switching 2-188.

Relay K1, CMOS analog switch U5B, and FETs Q20-Q23 select the input source voltage. For dc operation, the 22V range of the DAC assembly (A11) is brought in on the B IN and B FB lines from the Switch Matrix assembly (A8). For ac operation, the 22V range of the Oscillator Output assembly (A13) is brought in on the B IN and B FB lines. During calibration of the current functions, the 13V buffered dc reference BRF13 and BSRF13 are selected when K1 is set and U5B is closed.

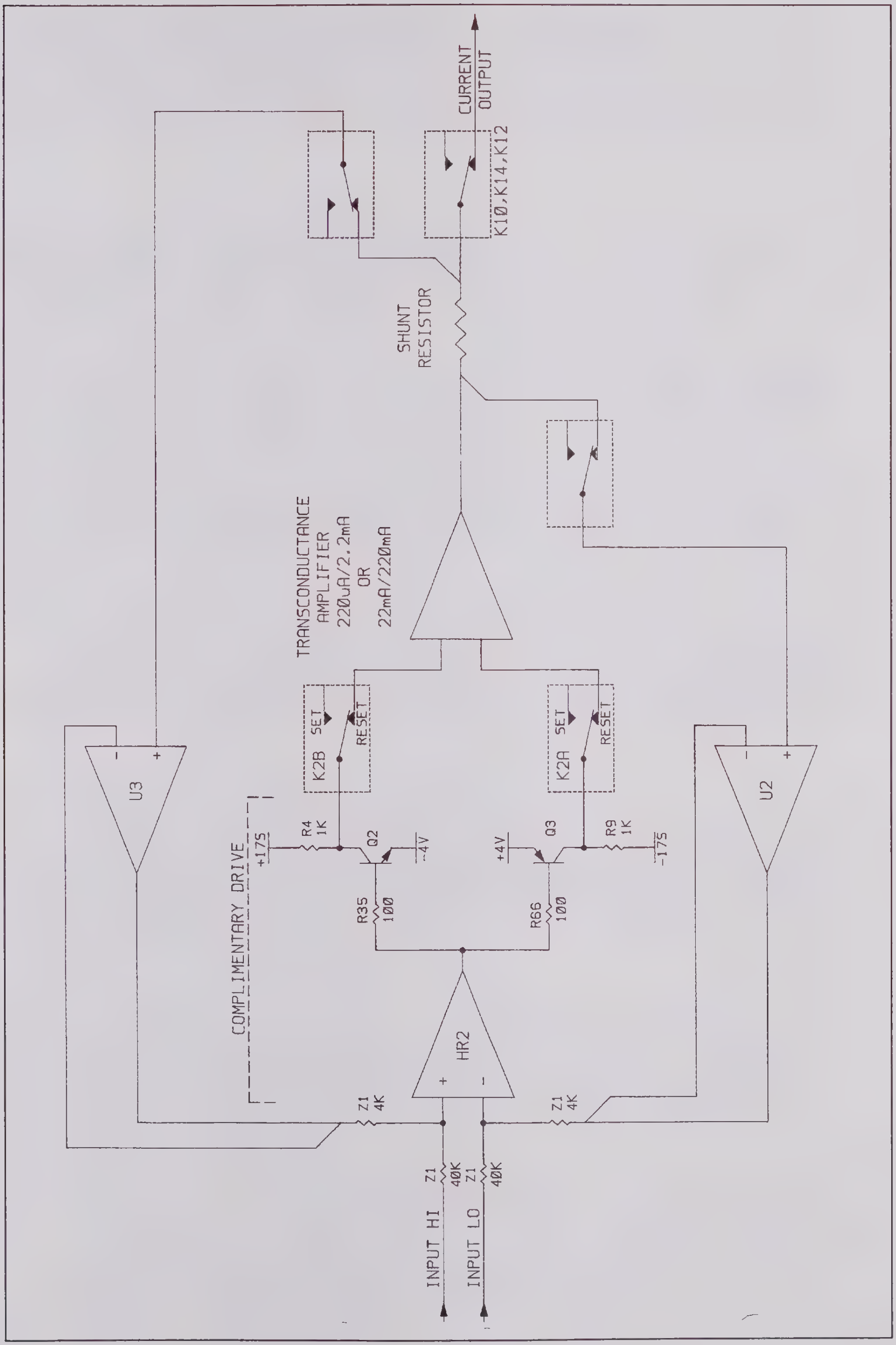


Figure 2-35. Current Output Simplified Schematic

The input signal return paths are selected for ac or dc operation by control lines FET1 and FET2, and NMOSFETs Q20-Q23. With a dc or 13V reference input, control line FET1 goes high, turning on Q21 and Q22, connecting RCOM and DAC OUT LO to the respective circuit. For ac current input, control line FET2 goes high, turning on Q20 and Q23, connecting OSC SENSE LO and OSCOM to the respective circuit.

Complementary Drive Circuit 2-189.

The circuitry containing transistors Q2, Q3, Q18 and Q19 provides the complementary drive to the output transconductance amplifiers from the single-ended output dc amplifier on hybrid HR2. Transistors Q2 and Q18 provide the drive during a positive input, while Q3 and Q19 provide the drive during a negative input. Relay K2 switches the drive to the 220 µA/2.2 mA transconductance amplifiers when reset, or to the 22 mA/220 mA transconductance amplifier when set.

The HR2 assembly consists of an op amp mounted on a heated-substrate hybrid, bonded to the shunt resistor network. The HR2 assembly gives this circuit excellent dc characteristics of low offset, noise and drift. The hybrid heater control circuit, outlined on sheet 2 of the schematic, adjusts the base voltage of Q1 to deliver the proper power to the heater resistor. This maintains the HR2 assembly at a constant temperature in spite of environmental temperature variations. Transistor Q14 protects the hybrid in case Q1 fails.

Transconductance Amplifiers 2-190.

The transconductance amplifiers are the 220 µA/2.2 mA range amplifier the 22 mA/220 mA range amplifier circuits. The 220 µA and 2.2 mA ranges are provided by the 220 µA/2.2 mA range transconductance amplifier, containing transistors Q4, Q5, and relay K3. With relay K3 reset as shown on schematic, the amplifier is in the 220 µA range. To place the amplifier in the 2.2 mA range, relay K3 is set so emitter resistors R10 and R12 are shunted by R11 and R13 respectively.

The 22 mA/220 mA range transconductance amplifier contains transistors Q6-Q13 and relay K4. It provides the 22 mA and 220 mA ranges. In the 22 mA range, the transconductance amplifier is composed of Q6-Q9 with K4 in the reset position. In the 220 mA range, the transconductance amplifier is composed of Q6-Q13 with K4 in the set position. In this range, Q10-Q13 are in the Darlington configuration with Q6-Q9 respectively. This provides the additional current gain needed for the 220 mA range.

Shunt Resistors 2-191.

A resistor network is used to sense the output current in each of the four current ranges. This network is composed of four four-terminal resistors attached to the heated substrate of HR2. The shunt resistors are 10 kΩ for the 220 µA range, 1 kΩ for the 2.2 mA range, 100Ω for the 22 mA range, and the 10Ω for the 220 mA range. Relays K5-K9 select the INPUT, OUTPUT, and SENSE binding posts for each of the four ranges as Table 2-15 shows.

Table 2-15. Relay Settings for Current Range Selection

Relay	Range			
	220 μA	2.2 mA	22 mA	220 mA
K5	R	S	S	S
K6	R	S	R	R
K7	R	S	R	R
K8	R	R	S	R
K9	R	R	R	S
S=SET R=RESET				

Feedback Loop 2-192.

The output current develops a 2.2V full-scale voltage across the appropriate shunt resistors. Buffer amplifiers U2 and U3 isolate the shunt from the remaining feedback circuit. The negative feedback buffer is op amp U2 configured as a voltage follower. The positive feedback buffer is made of U3 configured as a voltage follower.

Both the feedback voltage from U2 and U3, and the input voltage from K1 and Q20-Q23 are applied to the precision dual 10:1 matched voltage divider network Z1. Any voltage difference between the two halves of the network is amplified by the dc amplifier on the heated substrate hybrid HR2. This amplified dc is applied to the complementary drive circuit and in turn to the transconductance amplifiers to complete the feedback loop.

Therefore, with a 22V full scale input and the 10:1 divider, the voltage across the shunt network is forced to 2.2V by the feedback loop. The 2.2V across the shunt is developed by the full-scale output current on any of the four ranges. By programming the input voltage over a 10:1 range, the output current follows with a 10:1 range. By switching the shunt resistors, four 10:1 ranges give a total output range of 20 μA to 220 mA.

Current Output Switching 2-193.

Relays K10-K15 switch the output current for the various modes of operation required by this assembly. When K13 is reset, it switches in a dummy load (R14) to prevent transients during switching, and also for use during diagnostics. Non-latching relay K15 connects the return lines to the output whenever an output is called for. Non-latching relay K14 connects the output signal to latching relay K12. Relay K12 switches the output to the AUX CURRENT OUTPUT binding post while in the reset position, or to the OUTPUT HI binding post while in the set position.

The four ranges of output current can be connected to the B CUR line by relay K11. B CUR is routed to the rear-panel 5725A connector. This allows all current ranges to be available from the binding posts on the 5725A Amplifier if so selected by the operator.

Generation of the 2.2A Range 2-194.

To generate the 2.2A range, the Current assembly is set to the 22 mA range with its output directed to the High Voltage/High Current assembly (A15). This connection is made via the IHV line by relay K10 in the set position. The High Voltage/High Current assembly amplifies current by 100 to create the 2.2A range. This high current output is returned to the Current assembly via the B CUR line. Relay K11 in the set position directs it to the output relays, K12-K15, of the Current assembly.

During internal calibration of the 2.2A range, the Current assembly is set to the 22 mA or 2.2 mA range and directed to the High Voltage assembly in the same manner as previously described.

Internal calibration of the 2.2A range and gain of the High Voltage/High Current assembly is discussed further in the theory for the High Voltage assemblies.

Current Guard Buffer 2-195.

Buffer amplifier U4, configured as a voltage follower, is used to provide a guard voltage equal to the output voltage across the external load. The guard voltage, if used, prevents any output current from being shunted away from the load due to leakage or shunt capacitance in the system cabling.

Compliance Limiter 2-196.

A compliance limiter circuit consisting of Q24, Q25, and associated components clamps the output to ±11V during an over-compliance condition.

Current/Compliance Voltage Monitor 2-197.

The current/compliance voltage monitor circuit, which contains CMOS analog switch U5A, U5C, U5D, op amp U6, and associated components, measures the voltage on either side of the current shunts. This allows the Calibrator to detect an over-current or over-compliance condition. A logic low on control line FET3 closes U5A to connect the monitor circuit to the input side of the shunt resistor. The measurement at this point is the sum of the output compliance voltage and voltage drop across the shunt, which is proportional to the output current. A logic high on control line FET3 opens U5C, which allows pull-down resistor R36 to close U5D. This connects the monitor circuit to the output side of the shunt resistor, which gives the output compliance voltage.

Op amp U6 and associated components create an absolute value circuit whose output, CUR/COMP MONITOR, is always a positive dc voltage. During operation in the ac current function U6B generates a negative half-wave signal equal to the positive peaks of its input. Resistors R31 and R30 sum this half-wave signal and the input signal at the input of U6A. Capacitor C14 averages the voltage so the output of U6A is a dc voltage which represents the average value of the selected input.

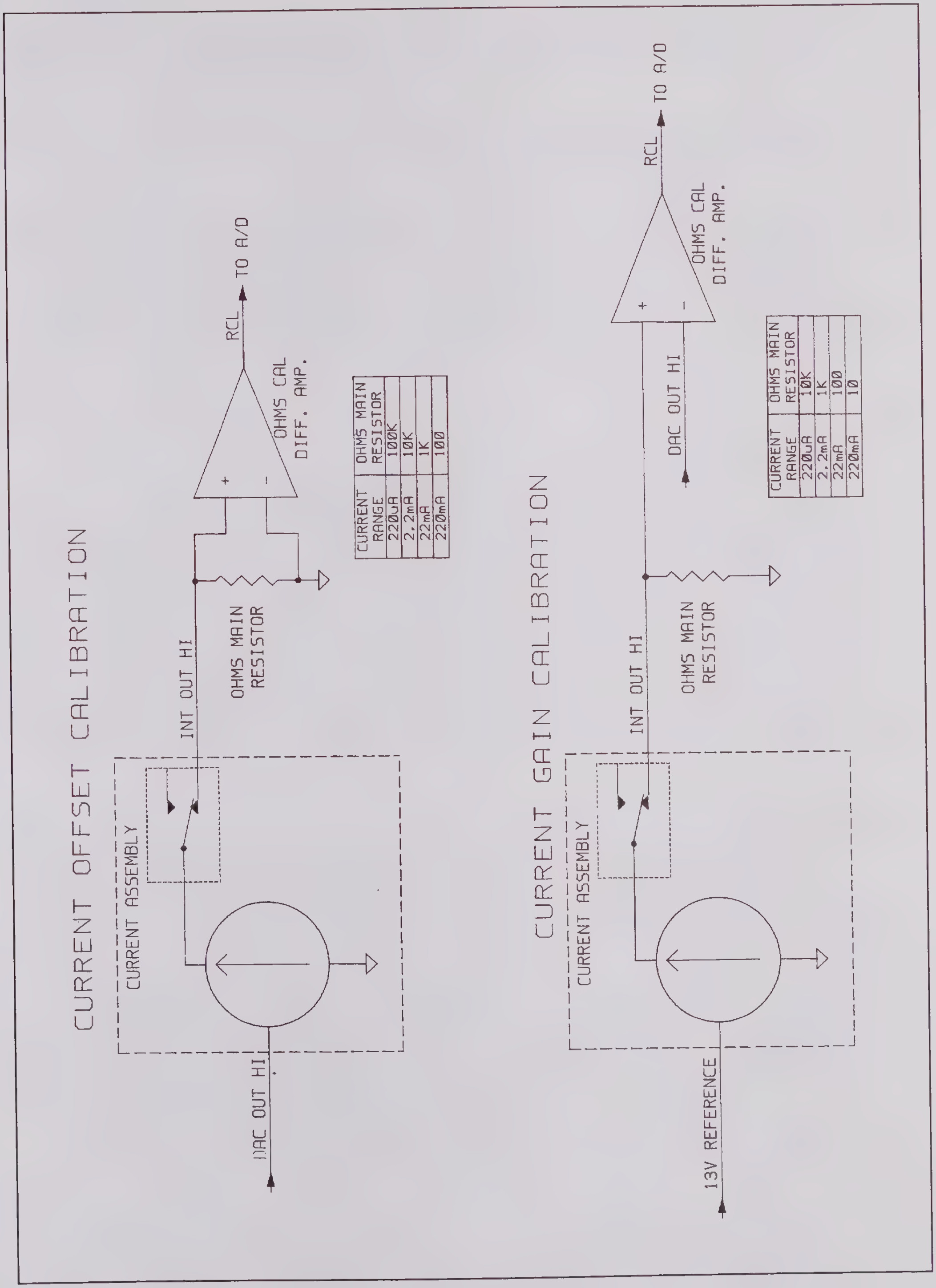
The diagnostic circuit connects CUR/COMP/ MONITOR to the SDL line, on which it is routed to the DAC assembly (A11) to be measured by the adc circuit. The calibrator software computes the difference between the two measurements and divides the result by the shunt value to determine the output current.

Current Assembly Calibration 2-198.

Refer to Figure 2-36 for the following discussion. Internal calibration of the Current assembly is a process of determining the offset and gain constants for each of the four current ranges.

To determine the offset of the 220 mA range, the Current assembly is set to the positive dc 220 mA range with its input from the DAC assembly set to 0V. The output of the Current assembly is routed to the Ohms Main assembly (A10), via INT OUT HI, where it is connected to the previously calibrated 100Ω resistor.

To get a checkpoint reading, the Current assembly output is removed from the 100/Q resistor on Ohms (via the output switching relays). The 100Ω resistor is connected to a differential amplifier on the Ohms Cal assembly (A9). The output of this differential



CURRENT RANGE	OHMS MAIN RESISTOR
220uA	100K
2.2mA	10K
22mA	1K
220mA	100

CURRENT RANGE	OHMS MAIN RESISTOR
220uA	10K
2.2mA	1K
22mA	100
220mA	10

Figure 2-36. Current Assembly Calibration

amplifier is connected to RCL, which is routed to the adc circuit on the DAC assembly. The adc circuit measures the voltage, which is the drop across the 100Ω resistor with no current applied through it. This value is the checkpoint reading and is stored in memory.

The output of the Current assembly is reconnected to the 100Ω resistor. Next, the DAC assembly, which is the Current input, is adjusted until the adc circuit measures the same reading as the check point.

Gain is determined by connecting the input of the Current assembly to the 13V reference BRF13 and BSRF13 via relay K1 and analog switch U5B. The resulting 130 mA from the Current assembly is routed via INT OUT HI to a previously calibrated 10W resistor on the Ohms Main assembly. The +input of the differential amplifier, located on the Ohms Cal assembly, is connected to one side of this 10W resistor and the -input of the differential amplifier is connected to the output of the DAC assembly. The output of the differential amplifier is connected to the adc circuit in the DAC assembly via the RCL line, and the DAC output is adjusted until a null is achieved. This determines the exact voltage drop across the 10W resistor. The exact gain can now be calculated using this and the previous offset reading.

The current output, now calibrated at dc, is further characterized for its frequency response. The Current assembly is configured to the ac current function with input from the Oscillator Output assembly (A13) set to 20V at a low frequency. The output side of the appropriate shunt resistor is connected to SCOM by relay K17B, and the resulting 2V on the input side of the shunt resistor is connected to the AC CAL line through U22 by relay K17A. The AC CAL signal is routed to the Oscillator Control assembly (A12) where a 400Ω rms sensor measures the ac voltage on this line. A dc reading of the sensor is taken. It and the Oscillator Output level are stored in memory. The Oscillator Output frequency is then increased and the Oscillator Output level is adjusted, and stored in memory, so the dc reading from the rms sensor is the same as the previous reading. This is repeated at various frequencies up to 10 kHz to characterize the entire frequency response of the ac current output.

High-Resolution Oscillator Section *2-199.*

The High-Resolution Oscillator supplies a square-wave signal (HI-RES) in the range of 10 Hz to 1.2 MHz with a frequency resolution of 4 1/2 digits. The output signal is routed on the motherboard P LOCK HI line to the Oscillator Output assembly, where it phase-locks the oscillator.

During calibrator operation using an external phase-lock signal, or during a non-ac operation, the Hi-Res Oscillator is shut off by control line HI RES ON/OFF from the digital control circuit. The hi-res circuitry uses a phase-locked loop circuit containing the reference frequency amplifier/divider, phase detector/divider, loop filter, and vco circuit as outlined on the schematic. A 5-500k divider and output switching circuitry creates the final output frequency. These circuits are described in the following paragraphs.

The Hi-Res Oscillator output is divided into five ranges as shown below:

- 10.00 Hz to 119.99 Hz
- 0.1200 kHz to 1.1999 kHz
- 1.200 kHz to 11.999 kHz
- 12.00 kHz to 119.99 kHz
- 0.1200 MHz to 1.1999 MHz

Note that the frequency resolution on each range changes from four digits for outputs of 12 to 99 to five digits for outputs of 100 to 119. For example, the output of range 1 has four digits of resolution from 10.00 Hz to 99.99 Hz and five digits resolution from 100.00 Hz to 119.99 Hz. The range 2 output has four digits resolution from 120 Hz to

990 Hz and five digits resolution from 1000.0 Hz to 1.1999 kHz. The resolution break points are similar for the other ranges.

Reference Frequency Amp/Divider 2-200.

A 2-MHz reference frequency is generated by the reference frequency amp/divider circuit as outlined on the schematic. This circuit uses the 8 MHz system clock lines CLK and CLK*, generated by the Guard Crossing assembly (A17). This 8 MHz signal is a low-level clock (200 mV p-p) and it is amplified to 5V p-p by comparator U13A. This 5V 8 MHz clock is turned off when the Hi-Res Oscillator is not being used by control line HI-RES ON/OFF from the digital control circuit and nor gate U15D. The 8 MHz clock is then divided to 2 MHz by flip-flops U14A and U14B to generate 2 MHz REF, which is the reference frequency for synthesizer IC U16. It is filtered by R63 and C49 to generate HI-RES CLOCK, which is monitored by the diagnostic circuit.

Phase-Locked Loop 2-201.

The phase-locked loop circuit contains the phase detector/dividers, loop filter, and vco (voltage-controlled oscillator) circuits as outlined on the schematic.

The phase det/dividers circuit contains synthesizer IC U16. This IC contains two programmable divide-by-n counters and a phase detector. The divide-by-n counters are controlled by inputs from the control bus, which are latched into internal latches on the IC. Information on the control bus is entered and latched into U16 by NOR gate U15A and control lines CS7* and WR*. The first divide-by-n counter is programmed to divide 2 MHz REF by 2000 to give 1 kHz, which is applied to one input of the internal phase detector. The other divide-by-n counter is used to divide the feedback frequency at pin 3, which is generated by the VCO circuit, by 6,010 to 12,000 in one-digit steps, and then apply it to the second input of the phase detector. The loop is locked when the two inputs to the phase detector are the same frequency and phase.

With the 1-kHz reference frequency and the feedback divider programmed between 6,010 and 12,000, the input frequency at pin 3 of U16 must be between 6.010 MHz and 12.000 MHz (1 kHz x 6010 = 6.010 MHz and 1 kHz x 12000 = 12.000 MHz).

Phase detector (U16) outputs ("0V" on pin 14 and "0R" on pin 15) are used by the loop filter circuit, which controls the VCO circuit. If the divided feedback frequency is greater than the 1 kHz reference frequency, or if the phase of the divided feedback frequency is leading the output, 0V pulses low and output 0R remains high. If the divided feedback frequency is less than the 1 kHz reference frequency, or if the phase of the divided feedback frequency is lagging the output, then 0R pulses low and output 0V remains high. When the feedback frequency and the 1 kHz frequency are the same and in phase, the outputs 0V and 0R both remain high except for a short period when both pulse low in phase. This condition occurs when the loop is locked.

Outputs from the phase detector (0V and 0R) are connected to the loop filter circuit which contains the two op amps in U20. U20A and U20B amplify and filter, respectively, any phase difference and apply it to varactor diode CR9 in the vco circuit.

The vco circuit contains varactor diode CR9 and vco IC U19. The vco frequency is controlled by CR9, which gets its bias voltage from amplifier U20. This circuit is designed to always operate over a 2:1 range from 6 MHz-12 MHz. To lock the loop, amplifier U20 changes the bias on varactor diode CR9 until the divided vco frequency has the same frequency and phase as the 1 kHz reference frequency at the input to the phase detector in U16. Once the loop is locked, the output of the phase-locked loop circuit is between 6 and 12 MHz. This output frequency is connected to the 5-500k divider circuit for further division.

Supply voltage is applied to vco U19 whenever the Hi-Res function is used by the circuitry containing analog CMOS switch U18A, transistor Q15, and zener diode VR3. VCO U19 is energized when control line HI-RES ON/OFF goes low to close U18A, which turns on transistor Q15, connecting zener diode VR3 to the -17LH power supply.

R53 and R54 divide the bias voltage input of the vco circuit to generate the HI-RES LOOP line, which is monitored by the diagnostic circuit.

5-500k Output Divider 2-202.

The 5-500k output divider circuit contains a synthesizer IC U17 which has a reference ® divider and a divide-by-N counter. These dividers are controlled by inputs from the CONTROL BUS, which are latched into internal latches on the IC. Information on the CONTROL BUS is entered and latched into U17 by NOR gate U15B and control lines CS13* and WR*. With the phase-locked loop output frequency locked at any frequency between 6 MHz and 12 MHz, divider U17 is programmed to divide by a value between 5 and 500,000 as required to produce the correct output frequency. The 6 MHz - 12 MHz input from the phase-locked loop circuit is divided by the reference divider to generate the 24 kHz-2.4 MHz frequency range at pin 18. This divided reference frequency is connected to pin 3, which is the input of the divide-by-N-counter. The divide-by-N counter further divides the signal to generate the 20 Hz-24 kHz frequency range at pin 15.

As an example, an output of 6.7 kHz is in range 3 with the loop locked at 6.7 MHz. (The internal divider in U16 is programmed to divide by 6,700, resulting in 6.700 MHz.) The two dividers in U17 are programmed for a total division of 500 (6.7 MHz/500 = 13.4 kHz). This 13.4 kHz signal is divided in half by the output switching circuit to generate the 6.7 kHz output.

Hi-Res Output Switching 2-203.

The output switching circuit contains three analog CMOS switches in U18, and flip-flops in U21. Flip-flop U21A divides the reference divider output of U17 by two to create the 12 kHz-1.2 MHz range. Flop-flop U21B divides the divide-by-N counter output of U17 by two to create the 10 Hz-12 kHz range. Control line HI-RES RANGE and NOR gate U15C control the analog CMOS switches U18B and U18C. These switches select the 12 kHz-1.2 MHz or the 10 Hz-12 kHz frequency range, respectively, from the flip-flops. Control line HI-RES ON/OFF and switch U18D connect this output square-wave signal to the P LOCK HI line when the variable phase output function is activated by the operator.

Table 2-16 shows how the dividers are set, the total division of the vco frequency, and the vco frequency. To determine the exact vco frequency, multiply the calibrator output frequency by the number in the total division bracket. For example, the output frequency is set to 42 kHz and the vco frequency is 42 kHz x 200 = 8.4 MHz. Note that the total division includes division by two by U21 in the output switching circuit.

Rear Panel Assembly (A21) *2-204.*

Functional circuitry on the Rear Panel assembly includes a relay control circuit, phase lock in/variable phase out I/O circuit, address mapping, clock regeneration circuit, IEEE-488 interface, RS-232-C interface, interfaces for the 5205A, 5215A, and 5220A amplifiers, and a 5725A Amplifier interface. Three amplifiers can be physically connected to the Calibrator: 5725A, 5220A with 5205A, or 5220A with 5215A. Only one can be used at a time. Depending on the amplifier's mode of operation, the output of the

Calibrator is either an ac or a dc voltage. The following theory of operation describes each of these circuits.

Rear Panel Power Supplies 2-205.

Power supplies are divided into guarded and unguarded. Unguarded supplies +5V LOGIC, +12V, and -12V are referenced to +5V LOGIC COMMON and are generated on the Digital Power Supply assembly (A19). Guarded supplies +5LH and -5LH are referenced to LH COM, and the supply +5RLH is referenced to RLH COM. These supplies are generated on the Regulator/Guard Crossing assembly (A17). Some ICs on the A17 assembly do not have power and ground pins shown on the schematic. This information is included in the table on sheet 1 of the Rear Panel schematic.

Table 2-16. Divider Settings and VCO Frequencies

Calibrator Output Frequency at TP16	U17 R Divider Setting	U17 N Divider Setting	Total Division of VCO at TP13	VCO Frequency at TP13
10 Hz to 12 Hz	500	1000	1M	10 MHz to 12 MHz
13 Hz to 15 Hz	400	1000	800k	10.4 MHz to 12 MHz
16 Hz to 30 Hz	200	1000	400k	6.4 MHz to 12 MHz
31 Hz to 60 Hz	100	1000	200k	6.2 MHz to 12 MHz
61 Hz to 120 Hz	50	1000	100k	6.1 MHz to 12 MHz
130 Hz to 150 Hz	400	100	80k	10.4 MHz to 12 MHz
160 Hz to 300 Hz	200	100	40k	6.4 MHz to 12 MHz
310 Hz to 600 Hz	100	100	20k	6.2 MHz to 12 MHz
610 Hz to 1.2 kHz	50	100	10k	6.1 MHz to 12 MHz
1.3 kHz to 1.5 kHz	400	10	8k	10.4 MHz to 12 MHz
1.6 kHz to 3.0 kHz	200	10	4k	6.4 MHz to 12 MHz
3.1 kHz to 6.0 kHz	100	10	2k	6.2 MHz to 12 MHz
6.1 kHz to 12 kHz	50	10	1k	6.1 MHz to 12 MHz
13 kHz to 15 kHz	400	0	800	10.4 MHz to 12 MHz
16 kHz to 30 kHz	200	0	400	6.4 MHz to 12 MHz
31 kHz to 60 kHz	100	0	200	6.2 MHz to 12 MHz
61 kHz to 120 kHz	50	0	100	6.1 MHz to 12 MHz
130 kHz to 150 kHz	40	0	80	10.4 MHz to 12 MHz
160 kHz to 300 kHz	20	0	40	6.4 MHz to 12 MHz
310 kHz to 600 kHz	10	0	20	6.2 MHz to 12 MHz
610 kHz to 1.2 MHz	5	0	10	6.1 MHz to 12 MHz

Rear Panel Address Mapping 2-206.

The rear panel decodes address lines from the bus connected to the main CPU through connector P91. Decoding is accomplished with a C22V10 PLD (U8) with the following chip selects:

- RPDUARTCS*, D00000-D0001F
- RPIEEECS*, D00020-D0002F
- Y52XXRD*, D00030-D00031
- Y5205WR*, D00032-D00033
- Y5220WR*, D00034-D00035

Clock Regeneration Circuit 2-207.

In order to minimize EMI (electro-magnetic interference) inside the Calibrator chassis, the rear panel accepts a low-level (~200 mV p-p sinewave) 3.68 MHz clock from the CPU assembly and conditions it to proper TTL clock levels.

This is done by a differential amplifier, U18, which amplifies the incoming signals 3.6864MHZCLK and 3.6864MHZCLK*. The output of U18 is a TTL level 3.68 MHz clock called RP3.68MHZ that is buffered by PLD U8 creating RPCLK for use by DUART (dual universal asynchronous receiver/transmitter) U5, and IEEE interface IC U2.

IEEE-488 (GPIB) Interface 2-208.

The IEEE-488 (GPIB) interface circuit provides the interface between the IEEE-488 connector (J1) and the calibrator processor on the CPU (A20) assembly. The circuitry uses a TMS9914 (U2) General Purpose Interface Bus (GPIB) adapter to meet the requirements for talker/listener operation on the IEEE-488 bus. This circuit translates asynchronous 8 bit data and control information, under control of an external controller, and converts this information to an acceptable format for the CPU. responds.

The TMS9914 has internal circuitry which handshakes in the proper GPIB protocol and stores data in an internal buffer. This IC also has the capability of interrupting the CPU. The CPU can then handle the interrupt through its own handler routine. The data lines between U2 and J1 are buffered by a 75160A (U3) data buffer, and the command lines are buffered by a 75162A (U4) command buffer. J1 is a standard IEEE-488 connector. The shell of this connector is tied to chassis ground for EMI/RFI shielding.

RS-232C Interface 2-209.

The RS-232C interface circuit uses a 68C681 DUART (U5), a 1488 line driver (U6), and a 1489 line receiver (U7).

The DUART does the parallel to serial data conversion and provides two channels of serial RS-232C communication.

The first channel is available to RS-232C connector J2 to meet serial interface needs between the Calibrator and the external world. The transmit line (*TXDA) is driven by U6D to TX of J2, pin 2. The receive line RX goes from J2, pin 3 through receiver U7C to the receive line *RXDA of the DUART.

The second channel is connected to the 5725A Amplifier interconnect connector (J7) to provide the 5725A digital control interface to the CPU assembly. Transmit line *TXDB is driven by U6B to B-SCT of J7, pin 18. Receive line B-SCR from J7, pin 17 goes through receiver U7B to the receive line *RCVB of the DUART. These lines are also connected to J10, pins 2 and 3, for internal software testing.

The DUART (U5) also has six input lines, four of which are used to monitor CTSA*, B-CINT*, CAL SWA*, and CAL SWB*. The CTS (clear to send) line from J2, pin 5 goes through receiver U7A becoming CTSA*. Line CAL SWA* comes from the rear panel CALIBRATION switch.

The B-CINT* input (5725A cable interlock) is a logic signal used to let the Calibrator know that the interface cable to the 5725A Amplifier is connected and the 5725A is energized.

The DUART (U5) generates four output lines. The first, RTSA*, is driven by U6C to the RTS (ready to send) pin 4 of J2. The remaining three are used in the auxiliary amplifier interface logic circuit.

5220EN* is the output enable for octal latch U10. 5220ADIR* is the output enable for buffer U11. 5205EN* is the output enable for octal latch U9.

Auxiliary Amplifier Interface 2-210.

The Auxiliary Amplifier interface connects the 5700A/5720A Series II to a 5205A or 5215A Precision Power Amplifier or the 5220A Transconductance Amplifier. The connection to the 5205A or 5215A is closed loop while the connection to the 5220A is open loop.

Three amplifiers can be physically connected to the 5700A/5720A Series II: 5725A, 5220A with 5205A, or 5220A with 5215A). Only one can be used at a time. Depending on the amplifier's mode of operation, the output of the Calibrator is either an ac or a dc voltage.

Relays on the Switch Matrix assembly connect OUTPUT HI signal to B IN, SENSE HI to B FB, and INT SENSE LO to B SNSLO, the driving signals for the 5205A, 5215A, and 5220A Auxiliary Amplifiers. These signals are routed to the rear panel from the motherboard through connector J8 and an external cable. The 5205A and 5220A configurations are described later.

5205A Interface 2-211.

The 5205A is a power amplifier with gain of -100 and a bandwidth of dc to 100 kHz. When the 5205A function is selected via the calibrator keyboard, the output of the calibrator is routed to connector J3 (pins 1, 9, 2, and 10) on the rear panel, which is closed-loop interfaced to the 5205A.

Note

Model 5215A is also compatible with the 5205A connector. The 5215A provides the same ac functions of the 5205A, but not the dc functions.

During this mode of operation, the calibrator is configured to the ac 11V range. Relay K1 is energized and relay K3 is set connecting B IN to 5205A INPUT HI, B FB to 5205A SENSE HI2, PA COM to 5205A INPUT LO, and B SNSLO to 5205A SENSE LO. Relay K4 is energized, connecting 5205A SENSE LO to 5205A SENSE L and 5205A SENSE HI to buffer amplifier U13. The output of buffer U13 is connected to K3 pin 9.

Relay K11 connects the 5205A voltage guard signal V-GRD2 to the Calibrator voltage guard V GUARD.

In addition to the ac signal, the 5700A/5720A Series II and 5205A interface is composed of four control lines and logic power. +5V LOGIC provides logic power for the opto-isolators in the 5205A and +5V LOGIC COMMON provides the return. The rear panel data bus, 5205AEN*, and Y5205WR* are used by latches in U9 to create control lines CONTROL and OPERATE to connector J3, pins 14 and 15, respectively.

CONTROL, when asserted low, places the 5205A in the "5200 Control" mode and sets up the 5205A for commands. OPERATE, when asserted low, commands the 5205A to go into operate.

The 5205A generates STATUS and TRIP signals that are connected to buffer U12 where they are monitored, via the DATA BUS and control line Y52XXRD*, by the Calibrator.

STATUS, when asserted low, indicates that the 5205A is in the operate mode. TRIP, when asserted low, tells the Calibrator that the 5205A has experienced a fault or overload and is no longer in the OPERATE mode.

5220A Interface *2-212.*

The 5220A is a transconductance amplifier with a gain of one. Its output range is from 0 to 20A, thus its input voltage is from 0 to 20V.

When the 5220A is selected via the front panel, the output of the Calibrator is routed to connector J4 on the rear panel, which is the interface to the 5220A.

The 5220A is designed to be operated with the Calibrator in an open loop configuration. In this mode of operation, relays K2 and K3 are reset and relays K1 and K5 are energized.

This configuration ties B IN to B FB and connects them to 5220A INPUT HI. B SNSLO and PACOM are tied together and connected to 5220A INPUT LO. In this mode, the Calibrator senses at the rear panel.

In addition to 5220A INPUT HI and 5220A INPUT LO, the interface between the Calibrator and 5220A is composed of ten control lines.

Lines BD0-BD3 form a four-bit bidirectional data bus. Data from the 5220A is buffered and read on the DATA BUS by buffer U12 and control line Y52XXRD*. Data to the 5220A is generated from the DATA BUS by latches in U10 and control lines 5220AEN* and Y5220WR*. This data is buffered by U11 and controlled by 5220ADIR* before connecting to J4, pins 4, 12, 3, and 11.

Lines BC0, BC2, BC3, and BC6 form a four bit address bus. This address is generated from the DATA BUS by latches in U10 and control lines 5220AEN* and Y5220WR*.

The 5220A generates status lines ACK* and WR*, which are connected to buffer U12 where they are monitored, via the DATA BUS and control line Y52XXRD*, by the Calibrator. ACK* is asserted low when a valid address is accepted by the 5220A. WR* is asserted low when its OK to read the 5220A status.

5725A Interface *2-213.*

The Calibrator is designed to work in close connection with the 5725A Amplifier. The rear panel in this system provides relay switching for the 5725A signals. The 5725A performs the same functions as both the 5205A and 5220A amplifiers. All voltage outputs from the 5725A are routed back to the binding posts on the Calibrator. All current outputs from the 5725A are sourced at the 5725A OUTPUT binding posts. You can configure the Calibrator to also source all its current outputs through the 5725A OUTPUT binding posts for convenience.

Connector J8 and Cable 4406 interface all the Calibrator I/O signals between the Motherboard and the rear panel. Connector J7 interfaces the Calibrator to the 5725A Amplifier. The interface between these two connectors is accomplished through relays K1, K2, and K6-K9. Relays K6-K9 break all the I/O lines except B-SENSE HI, B-OUT HI, V-GUARD, and B-IGRD, and connect them all to V-GUARD when the 5725A is not in use.

During 5725A operation, relays K1, K2, K6, and K7 switch the Calibrator analog signals B IN, B FB, B SNSLO, and PACOM to lines BOOST IN, B-FEEDBACK, B-SENSE LO, and BPA COM on connector J7.

High voltage output of the 5725A (B-OUT HI and B-SENSE HI) is connected to the Calibrator Motherboard via cable 4406 where it can be switched to the Calibrator binding posts by relays on the motherboard.

Relays K8 and K9 connect the 5725A current function lines I-RET, and B-CUR on connector J8 to B-IRTN, and B-CURRENT, on connector J7 when the 5725A is outputting Calibrator current (≤2.2A). Line B-RCL is used during 5725A calibration. Line B-RCL on J7 is connected to J8 through relay K6. Line B-RCL is routed via the motherboard to the Current assembly (A7) where it is switched to the calibrator RCL line by a relay.

Phase Lock In/Variable Phase out 2-214.

The Oscillator Output assembly (A13) can be phase locked to an external signal connected to the PHASE LOCK IN BNC connector J6. Relay K10B connects the shell of this BNC connector to chassis ground through protection resistor R19 when the Calibrator is on internal operation, or to P LOCK LO when the Calibrator is phase locked to the external signal coming in on J6.

This incoming signal is called PHLK IN on the schematic. Relay K10A switches an external phase-lock signal from J6 to the input of Q1 and Q2. FETs Q1 and Q2 provide current limiting for PHLK IN. Signal P LOCK is routed to connector J8 where it is connected to the Oscillator Output assembly via the Motherboard.

Components CR1, CR2, VR1, VR2, R4, and R5 provide amplitude protection for the phase lock circuitry on the Oscillator Output assembly by limiting the amplitude of P LOCK.

The Variable Phase Out BNC connector (J5) is connected to P SHIFT and its shell is connected to PA COM by energizing relay K12. Signal P SHIFT is a fixed-amplitude variable phase signal generated by the Oscillator Output assembly (A13). Refer to the Oscillator Output assembly theory of operation for a detailed description on the generation of P SHIFT. Resistor R18 serves as overcurrent protection for the BNC shell connection on J5.

Rear Panel Relay Control 2-215.

The relays on the Rear Panel assembly are used as the interfaces for the 5205A, 5215A, 5220A, or 5725A amplifiers, or for switching the PHASE LOCK IN and VARIABLE PHASE OUT signals.

The relay switching circuitry is under control of the guarded digital bus via connector J8. This guarded digital bus is generated on the Regulator/Guard Crossing assembly (A17).

The relay control circuitry is located on sheet 5 of the Rear Panel schematic. This circuit uses an 82C55 programmable peripheral interface (U14) and two relay drivers (U16 and U17) to control the 12 relays on this assembly and one relay (K12) on the Analog Motherboard. The 82C55 (U14), which is under control of the guarded digital bus via connected J8, has three ports generating 24 outputs.

Port A (PA0-PA7) provides the input lines for relay driver U16.

Port B (PB0-PB7) provides the input lines for relay driver U17.

PC0-PC2 of port C provides the CLEAR, STROBE, and OUTPUTENABLE lines for these relay drivers.

Relay Driver U16 controls two latching relays (K2 and K3) and four non- latching relays (K1, K4, K5, and K7). Relay driver U17 controls one latching relay (K6) and five non latching relays (K8-K12). Relay driver U17 also creates control line RLY12* (pin 13) which controls relay K12 on the Analog Motherboard assembly (A3).

Rear Panel CPU Interface 2-216.

The rear panel is interfaced to the CPU assembly (A20) via connector J8 on the rear panel. The CPU has:

- Five address lines (RPA1-RPA5) which comprise the ADDRESS BUS

- Seven control lines which comprise the CONTROL BUS
- A low-level 3.6864 MHz clock (CLOCK, CLOCK*)
- Eight data lines RPD0-RPD7

Interfacing between the Rear Panel data bus (D100-D107) and the CPU data bus (RPD0-RPD7) is done with a bus transceiver U1.

Wideband AC Module (Option -03) *2-217.*

The Option -03 Wideband AC Module consists of the Wideband Oscillator assembly (A6) and the Wideband Output assembly (A5).

The wideband module operates in conjunction with the Oscillator Output assembly (A13), and provides calibrated output voltages in the range of 300 μV to 3.5V rms at frequencies of 10 Hz to 30 MHz, into a 50Ω load resistance. The output impedance of the assembly is 50Ω. It is designed to drive 50Ω loads. The output of this option connects to the Type "N" wideband connector on the Calibrator front panel.

Theory of operation for the Wideband Oscillator assembly (A6) and the Wideband Output assembly (A5) follows under separate headings.

Wideband Oscillator Assembly (A6) *2-218.*

The Wideband Oscillator assembly generates sine wave outputs in the range of 1.1 MHz to 30 MHz, (with two-digit resolution) at a nominal full scale output of 700 mV rms.

The frequency source is a ECL-level square wave with a frequency range of 1.1 MHz to 30 MHz, created in the phase-locked loop and divider circuit. The amplitude of this square wave is controlled by the WB AMPLITUDE CONTROL line, which is a DC signal from the Wideband Output assembly, and the circuitry contained in the amplitude control amplifier.

The resulting variable frequency and amplitude square wave is converted to sine wave by one of the five-pole filters. This variable frequency and amplitude sine wave is routed to the Wideband Output assembly via connector J1 and a 75Ω coaxial cable.

Wideband Oscillator Power Supplies 2-219.

The +5LH, -5LH, +17S, and -17S supplies are generated on the Regulator assembly and routed to this assembly via the motherboard.

The -5LH supply is buffered by L12 and C49, creating the -5F supply.

The +5LH supply is divided by R66 and R67 to create the +2.5 supply which is the reference voltage for comparators in U7, U10, and U11.

Zener diode VR1 and resistor R39 create the +12 supply from the +17S supply. Zener diodes VR4 and VR5, resistors R40 and R41, and diodes CR8 and CR9 create the -12, -11, and -9.5 supplies from the -17S supply. These are used throughout the Wideband Oscillator assembly.

Wideband Oscillator Digital Control 2-220.

The digital control circuit on the Wideband Output assembly creates control lines WB MUXA, WB MUXB, WB MUXC, WB FBS, and WB ON/OFF*. These lines are routed to the Wideband Oscillator via the motherboard.

Control lines WB MUXA, WB MUXB, and WB MUXC are inverted and level-shifted by comparators in U7 to create the control lines for multiplexer U6. They are also used by the filter-select circuitry.

In this circuit, WB MUXA, WB MUXB, and WB MUXC are decoded by U8 to generate four control lines, These are inverted and level-shifted by comparators in U10 and U11. The output of these comparators create 16-32 MHz FILTER, 8-16 MHz FILTER, 4-8 MHz FILTER, 2-4 MHz FILTER, 1-2 MHz FILTER, and Q8/Q9 SELECT, which are used in the filter switch drive circuitry.

Control line WB FBS is inverted and level-shifted by a comparator in U10. This creates FILTER BAND SWITCH, which is also used in the filter selection circuitry. Control line WB ON/OFF* shuts down the 8 MHz clock generator and vco when the wideband module is not in use.

Phase-Locked Loop and Divider Circuit 2-221.

The phase-locked loop and divider circuit uses 8 MHz clock generator U15, synthesizer IC U1, amplifier U2, vco U3, and dividers in U4 and U5 to generate an ECL-level square wave from 1.1 MHz to 30 MHz.

The 8 MHz clock generator creates the 8 MHz reference frequency from the 8 MHz system clock lines CLK and CLK*, which is a low level (~200 mV p-p) 8 MHz sine wave generated on the Regulator/Guard Crossing (A17) assembly. Comparator U15 converts this sine wave into a TTL-level 8 MHz square wave to provide the reference frequency for synthesizer IC U1.

Synthesizer IC U1 contains two programmable divide-by-N counters and a phase detector. The divide-by-N counters are controlled by inputs from the guarded digital bus, which are latched into internal latches on the IC. NOR gates in U14 are used to gate the chip select (CS14) and write (WR) lines from the digital bus. This forms the strobe pulse necessary to latch the frequency data into the synthesizer IC.

The first divide-by-N counter is programmed to divide the 8 MHz reference by 160 to give 50 kHz. This, in turn, is applied to one input of the internal phase detector. The other divide-by-N counter is used to divide the feedback frequency at pin 3 by 80 to 160 in 1 digit steps, and then apply it to the second input of the phase detector. The loop is locked when the two inputs to the phase detector are the same frequency and phase.

With a 50 kHz reference frequency and the feedback divider programmed between 80 and 160, the input frequency at pin 3 (feedback frequency) must be between 4 MHz and 8 MHz. (50 kHz x 80 = 4 MHz and 50 kHz x 160 = 8 MHz.)

The frequency into U1 pin 3 is generated by the vco (U3) and dividers in U4 and U5. A flip flop in U4 divides the vco frequency by 2 and the binary counter in U5 further divides by 4 to give a total division of 8.

If the input to U1 pin 3 is between 4 MHz and 8 MHz, then the vco frequency before the divide-by-8 must be 32 MHz to 64 MHz.

The phase detector outputs ("0V" on pin 14 and "0R" on pin 15) of the synthesizer U1 are used by the amplifier (U2) to control the vco (U3). If the divider feedback frequency is greater than the 50 kHz reference frequency, or if the phase of the divider feedback frequency leads the output, then 0V pulses low while output 0R remains high.

If the divider feedback frequency is less than the 50 kHz reference frequency, of if the phase of the divider feedback frequency lags the output, then 0R pulses low and the output 0V remains high.

When the feedback frequency and the 50 kHz reference frequency are the same and in phase, the output 0V and 0R both remain high except for a small period when both pulse low in phase. This condition occurs when the loop is locked.

The vco frequency is controlled by varactor diodes, CR1 + CR2, which get their bias voltage from amplifier U2. Amplifier U2, which gets its input from the phase detector outputs (0V and 0R) of U1, changes the bias on varactor diodes CR1 and CR2 until the divided vco frequency has the same frequency and phase as the 50 kHz reference frequency at the input to the phase detector in U1.

Any phase difference is amplified by U2 and filtered by L6, C53, and C17 to bring the loop into lock.

The vco is shut off whenever the Wideband AC module is not in use. To shut off the vco control line WB ON/OFF* is set low and inverted by a comparator in U7 which then turns on Q3.

With transistor Q3 on, transistor Q2 is turned off which removes the -5V supply from the vco to stop the oscillation.

With the vco frequency between 32 and 64 MHz, U4 divides by 2 to give a symmetrical square wave of 16 to 32 MHz, which is the top octave range required for this assembly. Further division by two (pin 15), four (pin 13), eight (pin 4), and sixteen (pin 2) by binary counter U5 gives the other ranges required of 8 to 16 MHz, 4 to 8 MHz, 2 to 4 MHz, and 1 to 2 MHz.

Multiplexer U6, under software control via control lines WB MUXA, WB MUXB, WB MUXC, and comparators in U7, can be programmed to select which of the 5 ranges is needed to give the output frequencies of 1 to 32 MHz.

Amplitude Control Amplifier and X10 Wideband Amplifier 2-222.

The square wave output generated by the phase-locked loop and divider circuit (1-32 MHz OUTPUT) is connected to the amplitude control amplifier circuit.

This circuit uses transistor array U9 to form a differential gain-control amplifier. Gain of the amplifier is controlled by the dc signal AMPLITUDE CONTROL, connected to U9 pin 10.

DC signal AMPLITUDE CONTROL is generated by the thermal rms sensor amplitude control circuitry on the Wideband Output assembly (A5) and is discussed in that section.

The gain controlled square wave output of U9 (pin 6) is further amplified by the x10 wideband amplifier circuit. Transistors Q4, Q5, and Q6 are configured as an amplifier with a gain of ten. This amplifier raises the gain-controlled square wave to the level needed to drive output filters. The output of this circuit is a square wave with an amplitude between 1.4V p-p to 6.0V p-p.

Wideband Oscillator Filters 2-223.

Each of the five octave frequency ranges has a 5-pole filter to change the square wave input to a sine wave output with a nominal full scale output of 700 mV rms.

The filter switch drive circuit uses control lines from the filter select circuit (that contains transistor arrays U12 and U13) to provide the drive to properly turn on and off FETs and transistors in each of the filters.

The filter inputs and outputs are switched on by FETs and the filter output is applied to output driver Q7. The corresponding filter is selected automatically as each octave range is selected. The operation of the 16-32 MHz filter is described. The other four filters operate in a similar fashion.

The input FET Q101 is turned on via control line 16-32 MHz FILTER and a transistor in U13. This applies the signal FILTER INPUT from the X10 wideband amplifier to follower Q102. Transistor Q102 drives the filter that contains L102, L103, L104, C109 and C112. FET Q105 is turned on, in the same manner as FET Q101, to connect the sine wave output of this filter to FILTER OUTPUT. This is applied to output driver transistor Q7.

To obtain the required amount of filtering over the entire octave range, additional capacitors C110 and C111 are switched into the filter by PIN diodes CR102 and CR103 when operating below 70% of the full range (22 MHz in this case).

Diodes CR102 and CR103 are activated by turning on Q103 and Q104, respectively. Transistors Q103 and Q104 are turned on via control line Filter Band Switch and a transistor in U12.

Two additional FETs, Q8 and Q9, are used to isolate the 16-32 MHz filter and the 8-16 MHz filter, from the three other lower frequency filters, whenever the two high frequency filters are used. The isolation provided by FETs Q8 and Q9 eliminates both the input and output load capacity and circuit board capacity of the three lower frequency filters, so that follower Q6 can drive the high frequency filter input without distortion of the waveform. This also eliminates loading the filter outputs, which changes the filter frequency response.

Wideband Output Assembly (A5) *2-224.*

The Wideband Output assembly (A5) takes the sine wave signal from either the Wideband Oscillator assembly (A6) or the Oscillator Output assembly (A13), and amplifies it to a power level that drives 3.5V into a 50Ω load at the output.

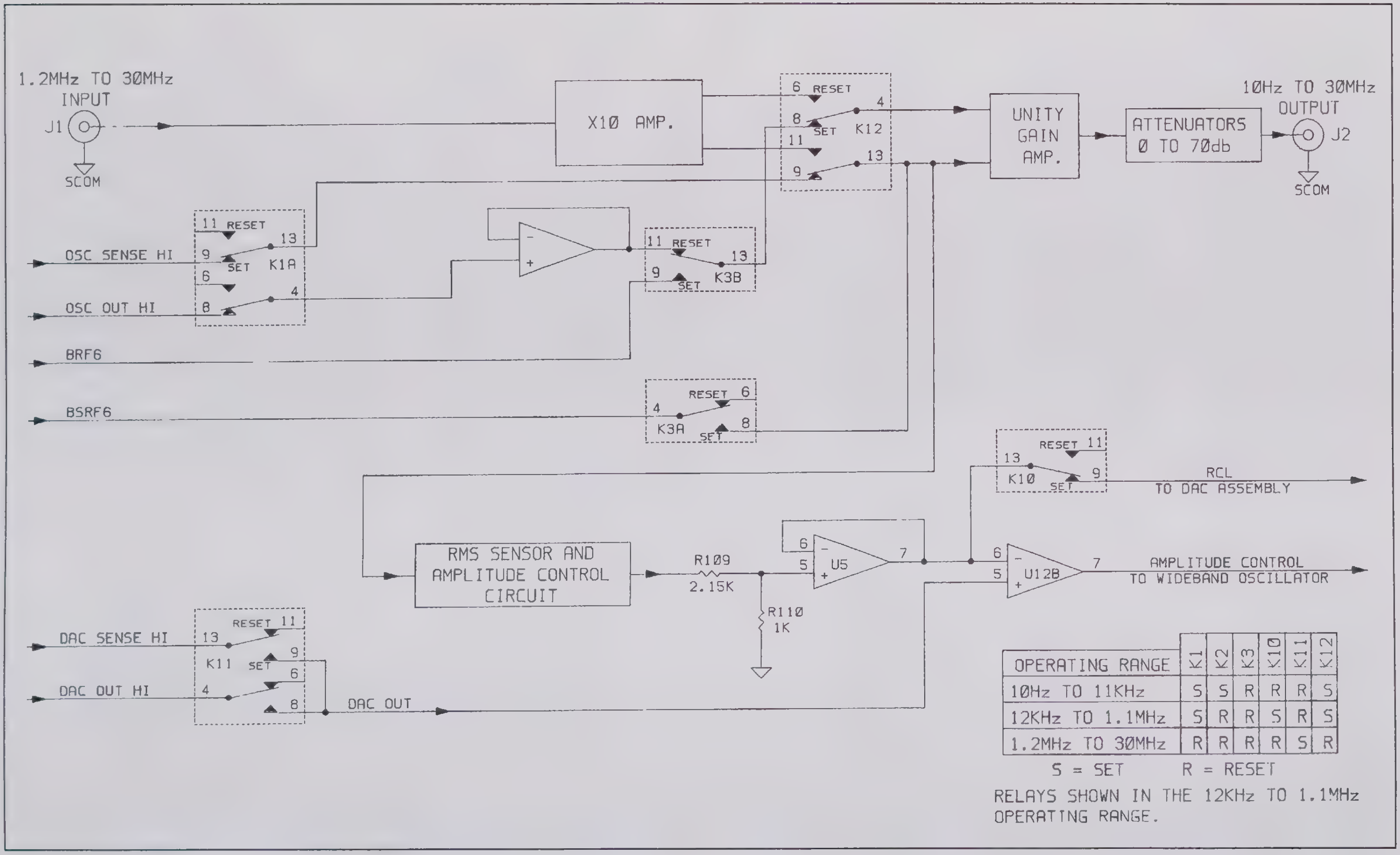
The Oscillator Output assembly generates the sine wave signal from 10 Hz to 1.1 MHz, and the Wideband Oscillator assembly generates the sine wave signal from 1.2 MHz to 30 MHz. This provides a total frequency range of 10 Hz to 30 MHz.

The Wideband Output assembly contains a power amplifier circuit that increases the gain and/or power level of the input signal. Also contained on the assembly are a thermal rms sensor circuit necessary for amplitude control, the 50Ω attenuators needed to reduce the output level through all of the amplitude ranges, an overload control circuit, and digital control circuitry.

Figure 2-37 is a simplified schematic for the Wideband Output assembly.

The Wideband Output assembly has three basic operating ranges:

1. The first range is for Wideband AC module operation at frequencies between 10 Hz and 11.9 kHz. In this frequency range, relay K1A is in the set position so the input signal is from the Oscillator Output assembly with its amplitude is controlled by the Oscillator Control assembly (A12). The amplitude control circuit on the Wideband Output assembly is only used for overload protection. This is done by control line PB0 which goes high and turns on FETs Q2 and Q3 via comparator U4B. These FETs shunt the rms sensor's input and output to ground through 200Ω resistors (R2 and R18) to reduce the sensitivity of the sensor.



OPERATING RANGE	K1	K2	K3	K10	K11	K12
10Hz TO 11KHz	S	S	R	R	R	S
12KHz TO 1.1MHz	S	R	R	S	R	S
1.2MHz TO 30MHz	R	R	R	R	S	R

S = SET R = RESET

RELAYS SHOWN IN THE 12KHz TO 1.1MHz OPERATING RANGE.

Figure 2-37. Wideband Output Assembly Simplified Schematic

1. The second range is for operation at frequencies between 12 kHz and 1.1 MHz. In this mode the input signal is also from the Oscillator Output assembly, but the amplitude is controlled by the amplitude control circuit on the Wideband Output assembly. Relay K10 is in the set position to connect the output of the rms sensor and amplitude control circuit to the RCL line where it is measured by the adc circuit on the DAC assembly. The DAC assembly operates in conjunction with the Oscillator Control assembly to adjust the amplitude of the Oscillator Output signal.
2. The third range is for operation at frequencies between 1.2 MHz and 30 MHz. In this mode the input signal is from the Wideband Oscillator assembly via connector J1. Its amplitude is controlled by the amplitude control circuit on the Wideband Output assembly. In this mode, the output of the DAC assembly, DAC OUT HI and DAC SENSEHI, are connected to DAC OUT by relay K11 in the set position. Op amp U12B compares DAC OUT to the output of the rms sensor and amplitude control circuit. Any difference between these two signals is amplified and routed to the Wideband Oscillator assembly via the AMPLITUDE CONTROL line. The Wideband Oscillator uses the Amplitude Control line to adjust its AC amplitude until the sensor output is equal to the DAC voltage.

Wideband Output Power Amplifier Circuit 2-225.

The power amplifier circuit, as outlined on sheet 1 of the Wideband Output assembly schematic, contains all the circuitry shown on sheet 2 of the schematic. This circuitry consists of the x10 amplifier, the unity-gain amplifier, and the 10 Hz to 1.1 MHz buffer circuit as outlined on the schematic.

The x10 amplifier circuit is used only during operation in the 1.2 MHz to 30 MHz range. The 1.2 MHz to 30 MHz sine wave input comes from the Wideband Oscillator assembly via a coaxial cable and connector J1. This input signal has a nominal full-scale amplitude of 700 mV rms.

The x10 amplifier circuit uses transistors Q4, Q5, Q6, Q7, Q8, Q9, and Q10 to amplify this signal by a factor of 10. Amplifier U11A keeps the DC offset on the output to near zero. The output of the X10 amplifier is applied to the unity gain amplifier by relay K12 in the reset position. The output impedance of the unity gain amplifier is 50Ω, therefore the x10 amplifier must produce 7.0V rms to give 3.5V rms into the 50Ω load.

The 10 Hz to 1.1 MHz buffer circuit is used during operation in the 10 Hz to 12 kHz range or the 13 kHz to 1.1 MHz range. In this mode, the input signal comes from the Oscillator Output assembly. This input signal is buffered by Q17 and applied to relay K12. Amplifier U11B keeps the DC offset on the output near zero for the 10 Hz to 1.1 MHz range.

The unity-gain amplifier is connected to either the output of the x10 amplifier or the output of the 10 Hz to 1.1 MHz Buffer by relay K12. The unity gain amplifier uses transistors Q11-Q16 and associated components. This circuit increases the power to a level that drives 3.5V rms into a 50 ohm load. The four 1/2-watt resistors in parallel (R96, R97, R98, R99) along with the output resistance of the amplifier form the 50Ω output resistance.

The output of this amplifier, called 10HZ TO 30MHZ OUTPUT, is a sine wave with an amplitude between 1.1V and 3.5V rms into 50Ω. This output signal is used by the attenuators to provide the overall output range of the Wideband Output assembly. Resistors R41 and R42, and capacitor C23 divide this output signal to create OUTPUT OFFSET for diagnostics.

Wideband Output Attenuators 2-226.

The 10 Hz to 30 MHz sine wave signal output of the power amplifier circuit connects to the 50Ω output attenuator composed of attenuator networks Z1 and Z2 and relays K4, K5, K6, K7, and K8.

Relay K4 switches the 10 dB attenuator into the circuit when activated or bypasses it when not activated.

Relay K5 switches the 20 dB attenuator into the circuit when activated or bypasses it when not activated.

Relays K6 and K7 switch the 40 dB attenuator into the circuit when activated and bypass it when not activated. The attenuator can thereby reduce the signal level in 10 dB steps from 0 to 70 dB.

Power Amplifier output amplitude is continuously variable over a 10 dB range, which when combined with the 0 to 70 dB attenuator, gives a continuous output range of 300 μV to 3.5V rms.

When energized, relay K8 enables the output signal to be connected to the output coaxial connector J2.

Wideband Output RMS Sensor and Amplitude Control Circuit 2-227.

The rms sensor circuit is used for:

- Amplitude control
- Overload control over the frequency range of 12 kHz to 30 MHz
- Overload control only over the frequency range of 10 Hz to 12 kHz

The rms sensor and amplitude control circuit is composed of U1, U2A, U2B, U3, U5, U12A, U12B, and associated components. Thermal sensor U1 provides a dc voltage equal to the rms value of the input voltage (at pin 6).

Input voltage to the thermal sensor comes from the power amplifier circuit. DC voltage output from the thermal sensor is connected to U2A configured as an integrator. The output of the integrator is connected to a square-root amplifier configured by U2B U3, and U12A, which keeps the settling time of the sensor constant.

The dc output of this sensor circuit (available at TP1) is buffered by U5. In the 12 kHz to 1.1 MHz range, the output of U5 is connected to the RCL line by relay K10 in the set position. In the 1.2 MHz to 30 MHz range, the output of U5 is compared by U12B to DAC OUT.

The DAC assembly (A11) output, DAC OUT HI and DAC SENSE HI, are tied together by relay K11 to create DAC OUT.

Relay K2A connects capacitor C7 into the rms sensor circuit in the 10 Hz to 11 kHz range to add additional filtering for low frequency signals.

Wideband Output Overload Control Circuit 2-228.

The overload control circuit contains comparator U4 (A and B), FETs Q2 and Q3, transistor Q1, and associated circuitry. This circuit protects the rms sensor and attenuators during an overload condition. Comparator U4A detects an overload condition by comparing the dc output of the rms sensor against a reference voltage.

The reference voltage is determined by zener diode VR2 and resistor R21. If the dc output of the rms sensor reaches a voltage 10% greater than the normal full-scale voltage, the output of U4A goes negative. This negative voltage causes a positive voltage at the output of U4B which turns on FETs Q2 and Q3. These FETs protect the rms sensor from damage by shunting its input and output to ground through the 200Ω resistors R2 and R18.

The negative voltage at the output of U4A also turns off transistor Q1 and causes control line U9 ENABLE to go high. This disables relay driver U9, which turns off all attenuator relays (K4-K7) and output relay K8.

Wideband Output Digital Control 2-229.

The heart of the Wideband Output assembly digital control circuitry is a 82C55 programmable peripheral interface IC (U7), which is under software control via the guarded digital bus.

This IC has three ports, generating 24 outputs. These outputs control three relay drivers (U6, U9, U10) and a 4051 analog multiplexer IC (U8) for self diagnostics.

Port A (PA0-PA7) is used as a common input bus for the relay drivers. Relay driver U6 controls latching relays K1, K2, K10, K11, and K12. Driver U6 is enabled by PC3 and strobed by PC2. Relay driver U9 controls non-latching relays K4-K8. Driver U6 is strobed by PC0 and enabled by control line U9 ENABLE, which is generated in the overload control circuit. Relay driver U10 controls latching relays K3 and K9. It is strobed by PC1 and enabled by PC3.

Relays K1 and K12 are controlled by the same drive lines and, when in the set position, select the input from the Oscillator Output (A13) assembly during operation between 10 Hz and 1 MHz.

Relay K9 connects a 50Ω load (R43 and R44 in parallel) to the RCL line where the adc circuit on the DAC assembly can monitor the output voltage and thereby determine proper operation of the output attenuator resistors and relays.

The 4051 analog multiplexer IC (U8) is used by self-diagnostic routines for the Wideband AC module. This allows the Calibrator to monitor three points on the Wideband Output assembly and one point on the Wideband Oscillator assembly. Points AMPLITUDE CONTROL, OUTPUT OFFSET, and SENSOR CAL are monitored on the Wideband Output assembly, and point PLL DIAGNOSTIC is monitored on the Wideband Oscillator assembly. PC4-PC6 of port C select which point the multiplexer monitors. PC7 enables the output of U8 to the SDL line where is measured by the adc circuit on the DAC assembly (A11).

Wideband Output Calibration 2-230.

Linearity of the rms sensor is determined by configuring the Wideband Output similarly to the second range of operation as described earlier. A difference is that the Oscillator Output assembly operates at 1 kHz instead of between 12 kHz and 1.1 MHz during operating in this range.

The Oscillator Output is set to 2.5V at 1 kHz. The resulting dc voltage from the rms sensor is connected to the RCL line by relay K10 in the set position. The RCL line is routed to the +input of the adc circuit on the DAC assembly, and the adc -input is connected to the DAC output. The difference between the two is measured and stored in memory. The Oscillator Output is increased to 7.0V and the difference between the two adc inputs is again measured. Software uses these values to determine the linearity of the rms sensor.

The previously calibrated 6.5V reference BRF6 and its sense line BSRF6, from the DAC assembly is used to calibrate the 10 dB, 20 dB, and 40 dB attenuators.

Relays K3 A and B and K12 are in the set position. This connects the 6.5V reference to the unity-gain amplifier and the attenuators. Output at the WIDEBAND Type "N" connector is connected back to the OUTPUT HI SENSE and OUTPUT LO SENSE binding posts.

Attenuation is calibrated starting with 70 dB and decreased in 10 dB steps to 0 dB. The Switch Matrix assembly connects the output of the Wideband AC module to its internal cal zero amplifier circuit during all attenuator calibrations except the 0 dB and 10 dB. The internal cal zero amplifier circuit provides a gain of 10 to Wideband output during 20 dB to 70 dB attenuation calibration. The output of this amplifier is connected to the RCL line which is routed to the +input of the adc circuit on the DAC assembly. Output from the DAC is connected to the -input of the adc circuit and adjusted until a null is achieved. The exact attenuator value is then determined.

Chapter 3
Calibration and Verification

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Introduction 3-1.

This chapter gives procedures for 5700A/5720A Series II calibration, verification, acceptance testing, and performance testing. Information here applies to testing the performance of and calibrating a normally operating 5700A/5720A Series II. In case of malfunction, refer to Chapter 5, Troubleshooting, which explains how to use self diagnostic tests to identify a faulty module. Calibration and Performance Testing is presented in the following three parts:

- Calibration, which is to be done at the beginning of every calibration cycle. This is the same procedure as in Chapter 7 of the *5700A/5720A Series II Operator Manua*l. It uses three external standards; 1Ω, 10 kΩ, and 10V dc. The procedure is repeated here for convenience. Also included in this part are procedures for doing Calibration Check and Range Calibration.
- Full Performance Verification, which is the full verification procedure, recommended every two years. Part of this procedure is Wideband AC Module (Option 5700A-03) flatness calibration, also recommended only every two years.

Optional Tests, which are recommended following repair or for use in acceptance testing. These tests include such checks as load regulation, noise, and distortion. These tests are not required on a routine basis. They are not necessary after a Calibrator passes Full Performance Verification.

Accessing the Fuse 3-2.

The fuse is accessible from the rear panel. The fuse rating label to the right of the fuse holder shows the correct replacement fuse ratings for each operating voltage. To access the fuse, refer to Figure 3-1 and proceed as follows:

1. Disconnect line power.
2. Using a standard screwdriver, turn the fuse holder counterclockwise until the cap and fuse are disengaged.

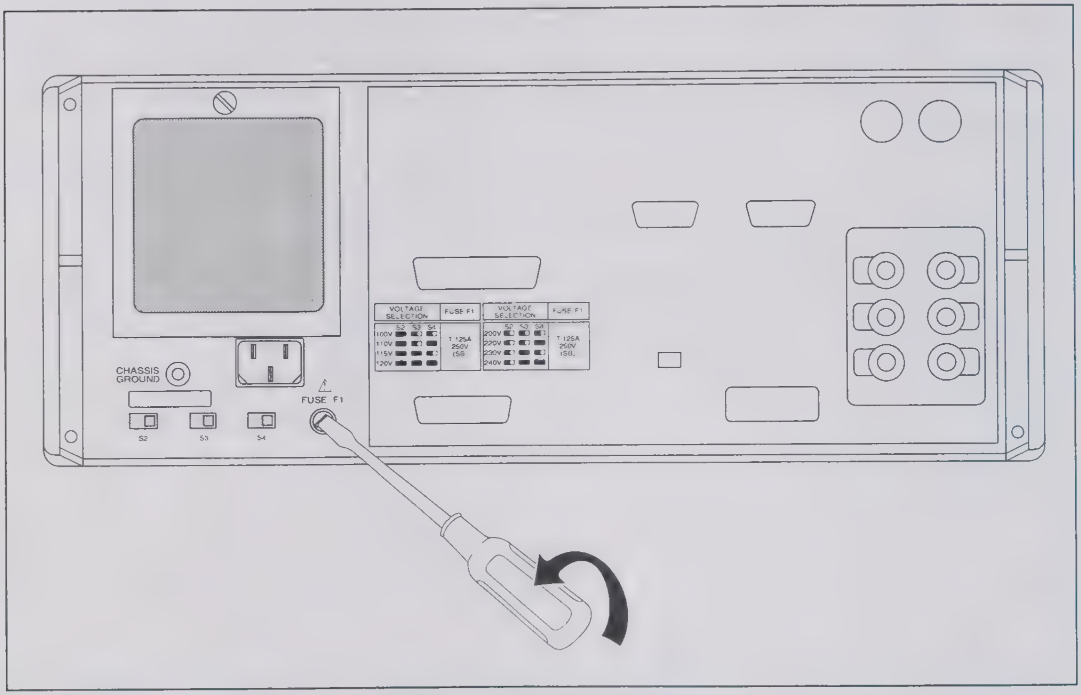


Figure 3-1. Accessing the Fuse

Cleaning the Air Filter *3-3.*

Caution

Damage caused by overheating may occur if the area around the fan is restricted, the intake air is too warm, or the air filter becomes clogged.

The air filter must be removed and cleaned at least every 30 days, or more frequently if the calibrator is operated in a dusty environment. The air filter is accessible from the rear panel of the calibrator.

To clean the air filter, refer to Figure 3-2 and proceed as follows:

1. Disconnect line power.
2. Remove the filter by unscrewing the knurled screw at the top of the air filter pulling the filter's retainer downwards (it hinges at the bottom) and removing the filter element.
3. Clean the filter by washing it in soapy water. Rinse and dry it thoroughly before reinstalling.
4. Reinstall the filter and the knurled screw.

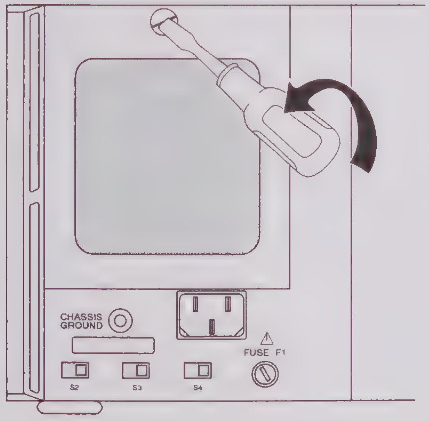


Figure 3-2. Accessing the Air Filter

Cleaning the Exterior *3-4.*

To keep the calibrator looking like new, clean the case, front panel keys, and lens using a soft cloth slightly dampened with either water or a non-abrasive mild cleaning solution that is not harmful to plastics.

Caution

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They can damage the plastic materials used in the calibrator.

Calibration *3-5.*

This chapter provides procedures for calibrating the 5700A/5720A Series II to external standards, adjusting the range if necessary, and for performing a calibration check.

Your calibrator is calibrated at the factory with constants that are traceable to NIST. In order to maintain traceability, you only need to met the following requirements.

- Calibration to external standards must be completed at the beginning of the calibration cycle
- Performance verification must be completed every two years.
- Zero Calibration must be performed every 30 days (refer to the *5700A/5720A Series II Operators Manual*).

Calibration check and range calibration are optional procedures that are provided for enhancing the accuracy if needed for special requirements.

Calibrating the 5700A/5720A Series II to External Standards *3-6.*

You must calibrate to external standards at the beginning of the calibration cycle. The length of the cycle (24 hours, 90 days, 180 days, or one year) is selected in a setup menu described in Chapter 4 of the *5700A/5720A Operators Manual*.

To calibrate the 5700A/5720A Series II, you apply three portable standards to the output binding posts: a 10V dc voltage standard, a 1Ω resistance standard, and a 10 kΩ resistance standard. The following standards are recommended:

- Model 732A or 732B DC Reference Standard
- Model 742A-1 1Ω Resistance Standard
- Model 742A-10k 10Ω Resistance Standard

Use the following Low Thermal Leads for all connections:

- When calibrating the 5700A, use either the connector set 5440A-7002 (banana plugs) or the set 5440A-7003 (spade lugs).
- When calibrating the 5720A, use the set 5440A-7003 (spade lugs).

Warning

Operator accessible LETHAL VOLTAGES may be present on the lugs at the end of these cables when used with instrumentation capable of producing such voltages. These cables should be used only when thermal emf performance is required. For other applications, cables with operator protection form contact with high voltages should be used.

Calibration Requirements 3-7.

Both the calibrator and the recommended external standards have the ability to internally control (or compensate for) ambient temperature variations. Therefore it is unnecessary to keep the calibrator in tightly controlled temperatures during calibration. During the calibration procedure, the calibrator prompts you to enter the ambient temperature, and includes this information in specification readouts and output shift reports.

When to Adjust the Calibrator's Uncertainty Specifications 3-8.

Table 3-1 lists each external standard's uncertainty limit, and the 5700A/5720A Series II uncertainty specifications that must adjusted accordingly if that limit is exceeded.

As long as the external standards have the uncertainties listed in Table 3-1, you do not need to adjust the calibrator's absolute uncertainty specifications in Chapter 1. However, if your standard's uncertainty exceeds the value in the table you must adjust some of the calibrator's absolute uncertainty specifications by the algebraic difference between your standard's uncertainty and the uncertainty limit listed in the Table 3-1. For example, if the dc voltage standard has an uncertainty of ±2.5 ppm, then the 5700A and the 5720A absolute uncertainty specifications listed in Table 3-1 for the traceable quantity of voltage must all be increased by ±1 ppm.

Table 3-1. Standards for Calibrating 5700A/5720A Series II

Fluke Standard	Traceable Quantity	Nominal Value	Uncertainty Limit	5700A/5720A Series II Specifications susceptible to Uncertainty Limit
732B	Voltage	10V	±1.5 ppm	dc volts, ac volts, dc current, ac current
742A-1	Resistance	1Ω	±10 ppm	1Ω, 1.9Ω
742A-10k	Resistance	10 kΩ	±4 ppm	ac current, dc current 10Ω to 100 MΩ

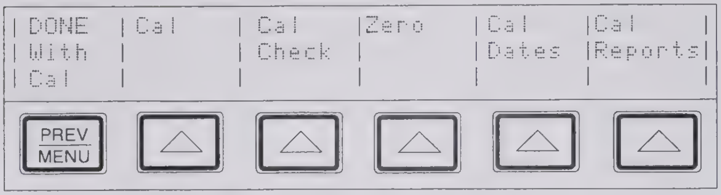
Calibration Procedure 3-9.

Before you being this procedure make sure the calibrator is powered on and has completed the appropriate warm-up period.

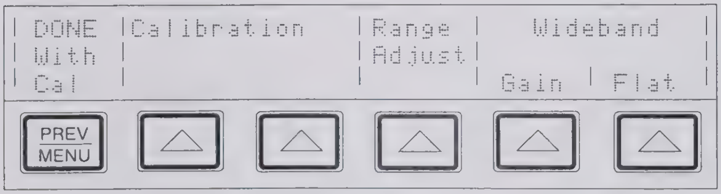
After you have finished calibration, but before you save the new constants, the calibrator presents the new changes as ± ppm, and as a percentage of specifications for each range and function. A list of changes can be sent to a computer through either the serial or instrument control (IEEE-488) port, or printed through the serial port. The largest proposed change will be displayed on the calibrator's front panel.

Follow this procedure to calibrate the main output functions.

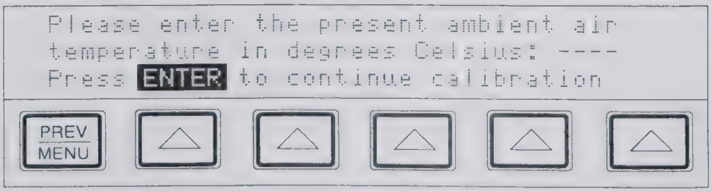
1. Press the "Setup Menus" softkey; then press the "Cal" softkey. The calibration menu appears as shown below:



2. Press the "Cal" softkey. The display shows the following.

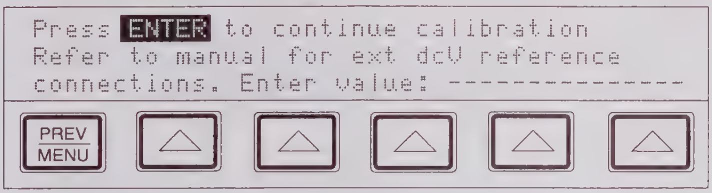


3. To calibrate the main output functions, press one of the softkeys under "Calibration." The display shows the following:



Please enter the present ambient air
temperature in degrees Celsius: ----
Press ENTER to continue calibration

4. Enter the ambient temperature; then press ENTER. The display shows:



```
Press ENTER to continue calibration
Refer to manual for ext dcV reference
connections. Enter value: ---------------
```

5. Connect the 732B to the calibrator as shown in Figure 3-3.

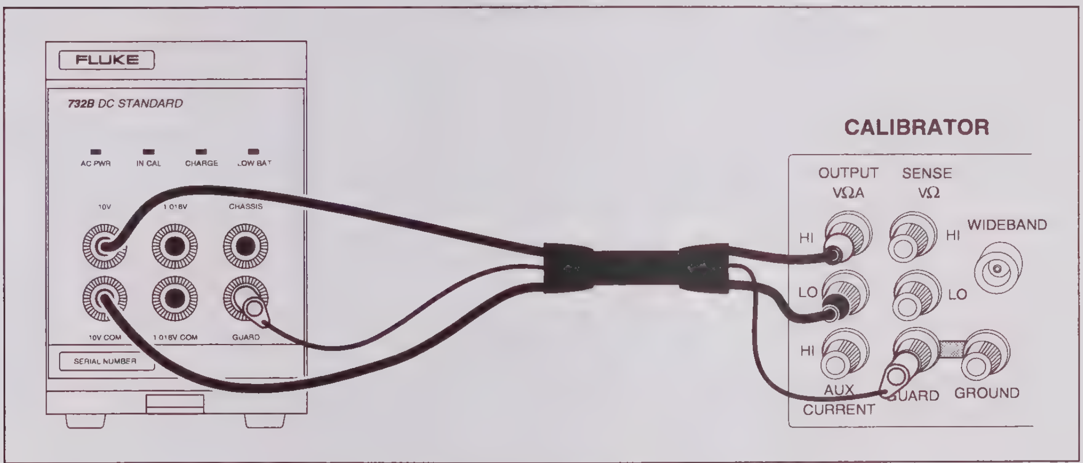
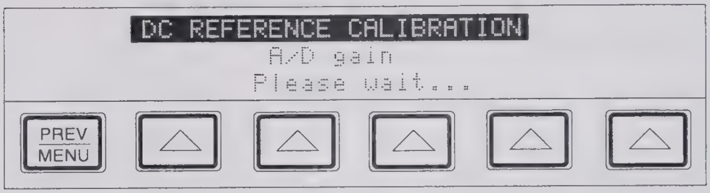


Figure 3-3. 732B External Calibration Connections.

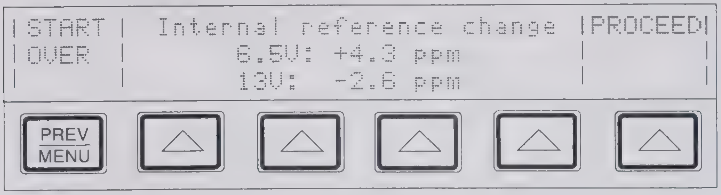
6. Enter the true value of the 732B 10V output. The true value is the value printed on the calibration sticker, plus or minus, as well as drift that has occurred since calibration. That drift can be estimated provided control charts have been maintained for the 732B.

   If the entered value is not between 9V and 11V, and error message appears, which lets you start over from this point with a calibrated 732B. Press ENTER, and the display shows the following:



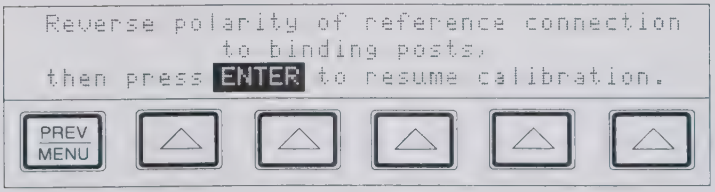
```
DC REFERENCE CALIBRATION
A/D gain
Please wait...
```

   When the calibrator's 6.5V and 13V references have been characterized, the display shows the following message, which lets you accept or reject the changes that are about to be made to the calibration constants.



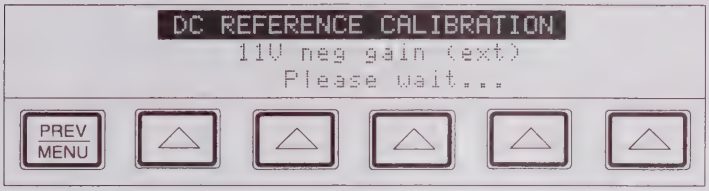
```
|START |  Internal reference change |PROCEED|
|OVER  |        6.5V: +4.3 ppm      |       |
|      |        13V:  -2.6 ppm      |       |
```

7. To reject the changes, return to the calibration menu shown in step 2 by pressing PREV MENU. Otherwise, press the softkey under "Proceed" to accept and save the changes, and to open the display shown below, letting you continue with calibration.

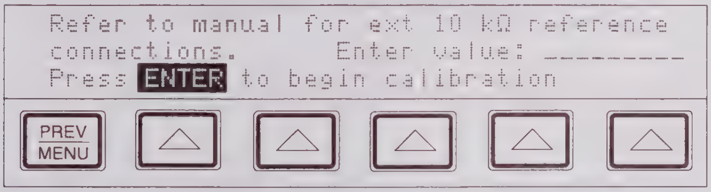


```
Reverse polarity of reference connection
to binding posts,
then press ENTER to resume calibration.
```

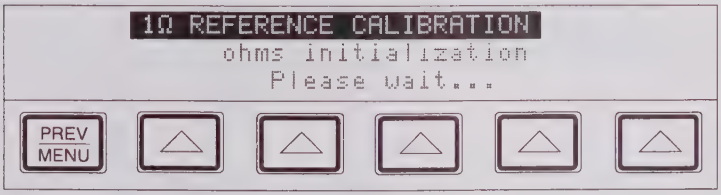
8. Reverse the HI and LO connections at the 732B terminals, and press ENTER. The following displays appear, asking you to wait before proceeding with the 10 kΩ standard.


DC REFERENCE CALIBRATION
11V neg gain (ext)
Please wait...

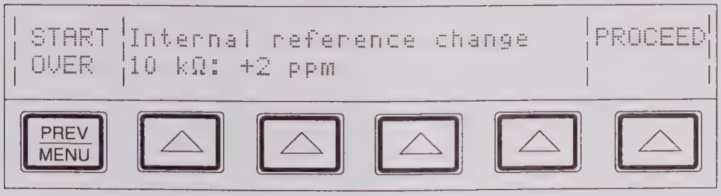
After a few seconds, the following display appears:


Refer to manual for ext 10 kΩ reference
connections. Enter value: _________
Press ENTER to begin calibration

9. Connect the calibrator to the 10 kΩ standard as shown in Figure 3-4 and enter the true value of the standard. If the standard is not between 9 kΩ and 11 kΩ, an error message appears, which allows you to start over from this point with a different standard. Press ENTER again to open the following display:


1Ω REFERENCE CALIBRATION
ohms initialization
Please wait...

When the internal 10 kΩ reference has been characterized, the following message appears, which lets you accept or reject the changes that are about to be made to the calibration constant:


Internal reference change
10 kΩ: +2 ppm

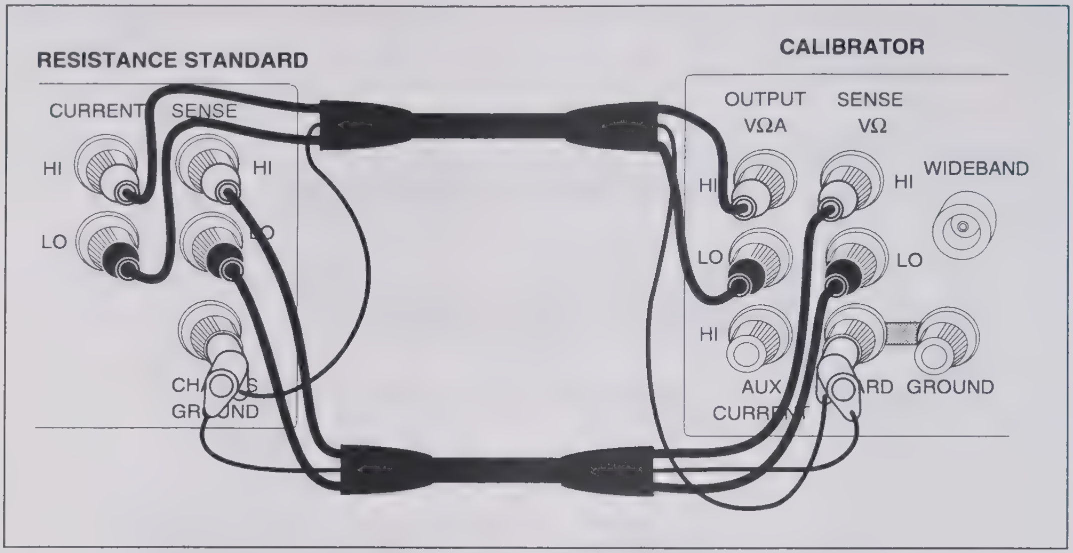
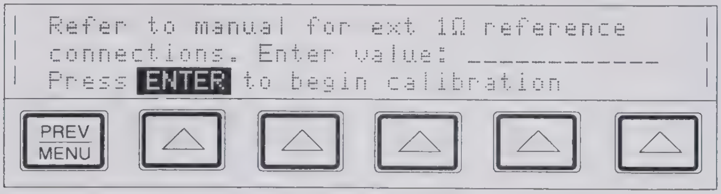


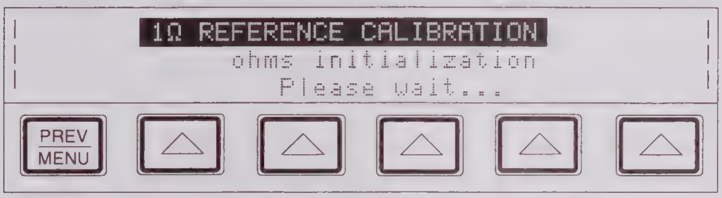
Figure 3-4. 742A-1 and 742A-10k External Calibration Connections

10. To reject the changes, return to the calibration menu shown in step 2 by pressing PREV MENU. Otherwise, press the softkey under "Proceed" to accept and save the changes, and to open the display shown below, letting you continue with calibration.



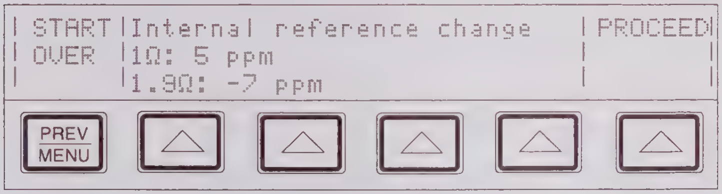
```
Refer to manual for ext 1Ω reference
connections. Enter value: ___________
Press ENTER to begin calibration
```

11. Disconnect the 10 kΩ standard, and connect the calibrator to the 1Ω standard; then enter the true value of the 1Ω standard. If the standard is not between 0.9Ω and 1.1Ω, an error message appears, which lets you start over from this point with another standard. Press ENTER to bring up the following display:



```
1Ω REFERENCE CALIBRATION
  ohms initialization
     Please wait...
```

When the internal 1Ω reference has been characterized, the following message appears, which lets you accept or reject the changes that re about to be made to the calibration constant:



```
START |Internal reference change   |PROCEED
OVER  |1Ω: 5 ppm
      |1.9Ω: -7 ppm
```

12. To reject the changes, return to the calibration menu shown in step 2 by pressing PREV MENU. Otherwise, press the softkey under "Proceed" to accept and save the changes, and let the calibrator complete the internal calibration steps.
13. The calibration is not effective until you store the newly calibrated constants in memory. To store the constants, set the rear panel CALIBRATION switch to ENABLE, the press the "Store Values" softkey.

Note

To review the proposed output shifts before you store the new constants, print a listing of the proposed shifts by pressing the softkey under "Print Output Shifts."

14. After you store the constants, press the softkey under "DONE with Cal" to exit calibration and resume normal operation.
15. If you press this softkey before you store the constants, the new constants will be used temporarily for normal operation until the calibrator is powered down or reset. (This is only true for software versions G and lower. For versions H and higher, the process is aborted without updating existing constants.)
16. You have now completed the wideband gain calibration. Set the rear panel CALIBRATION switch to NORMAL.

Range Calibration 3-10.

Once calibration is complete, you may find you need to make further adjustments to the range. Calibrating the range is accomplished by adjusting a range constant, which is an additional gain multiplier. Although range calibration is not needed in order to meet total uncertainty specifications, it is useful for tuning the calibrator so that its values are closer to your own standards.

Use your own laboratory standard to adjust the range constants. The following procedure for adjusting the range constants is designed for laboratory standard values that are between 45% and 95% of the range's full-scale value.

Once you adjust the range constant, the new constant remains active until the next calibration, at which time all range constant multipliers are rest to 1. You can also erase all range adjustments by calling up the format EEPROM menu and selecting Range Constants (refer to Chapter 4 of the *5700A/5720A Operators Manual*).

Before you begin the following procedure, make sure you have the equipment you need on hand including your own laboratory standards where required.

The following example procedure adjusts the 220V dc range constant using the following equipment:

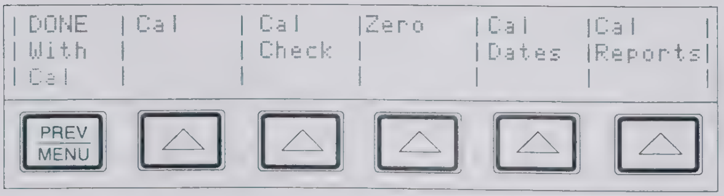
- 732B DC reference standard
- 752A Reference Divider
- 845AB/845AR Null Detector
- Low Thermal Test Leads: 5440A-7002 (banana plugs) or 5440A-7003 (spade lugs)

Warning

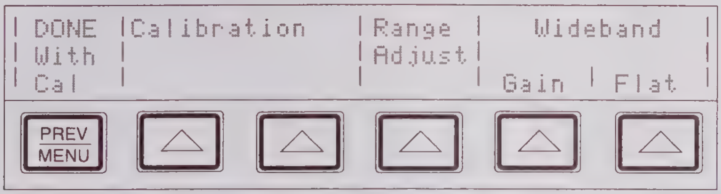
Operator accessible LETHAL VOLTAGES may be present on the lugs at the end of the 5440A-7003 cables when used with instrumentation capable of producing such voltages. These cables should be used only when thermal emf performance is required. For other applications, cables with operator protection form contact with high voltages should be used.

Proceed as follows to adjust the 220V dc range constant. You must have completed calibration to external standards before you follow this procedure.

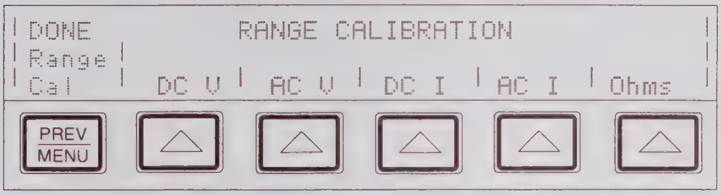
1. Press the "Setup Menus" softkey; the press the "Cal" softkey. The following menu appears:



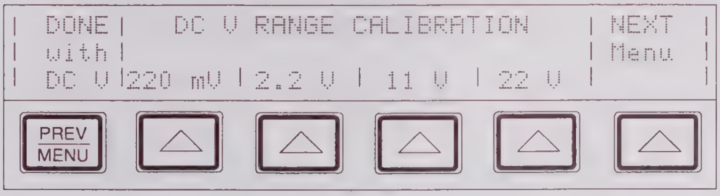
2. Press the "Cal" softkey to bring up the next menu shown below:



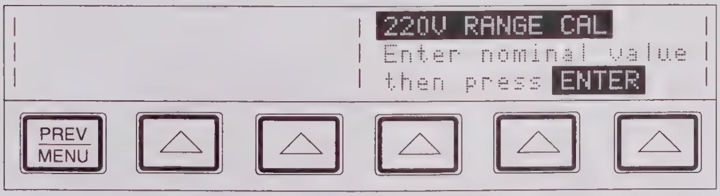
3. Press the "Range Adjust" softkey to bring up the next menu shown below:



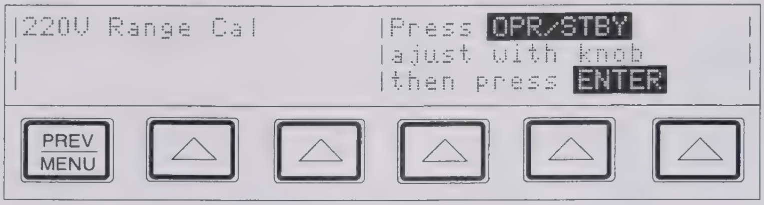
4. Press the "DC V" softkey to bring up the next menu shown below:



5. Press the "NEXT Menu" softkey, which scrolls through all the available dc voltage ranges, until 220V appears. Then press that selection's softkey to open a display similar to the following:



6. Connect the 732B, 845A, and 732B in a 10:1 configuration, as shown in Figure 3-5.
7. Multiply the 732B's value by 10, and enter this new value. (This value is the output of the 752A, to which you will null the calibrator's output.) Then press ENTER to bring up the following display.



```
|220V Range Cal        |Press OPR/STBY    |
|                      |ajust with knob   |
|                      |then press ENTER  |
```

8. Press OPR/STBY to activate the calibrator output. Then turn the output adjustment knob on the calibrator until you achieve a null on the 845A Null Detector.
9. Se the rear panel CALIBRATION switch to ENABLE. Press ENTER on the front panel. The calibrator will now calculate a new range constant multiplier for the 220V dc range, and will store it in non-volatile memory.
10. The range calibration is now complete. Set the rear panel CALIBRATION switch to the NORMAL position, disconnect the external standards, and press RESET to reset the calibrator to its newly calibrated ranges.

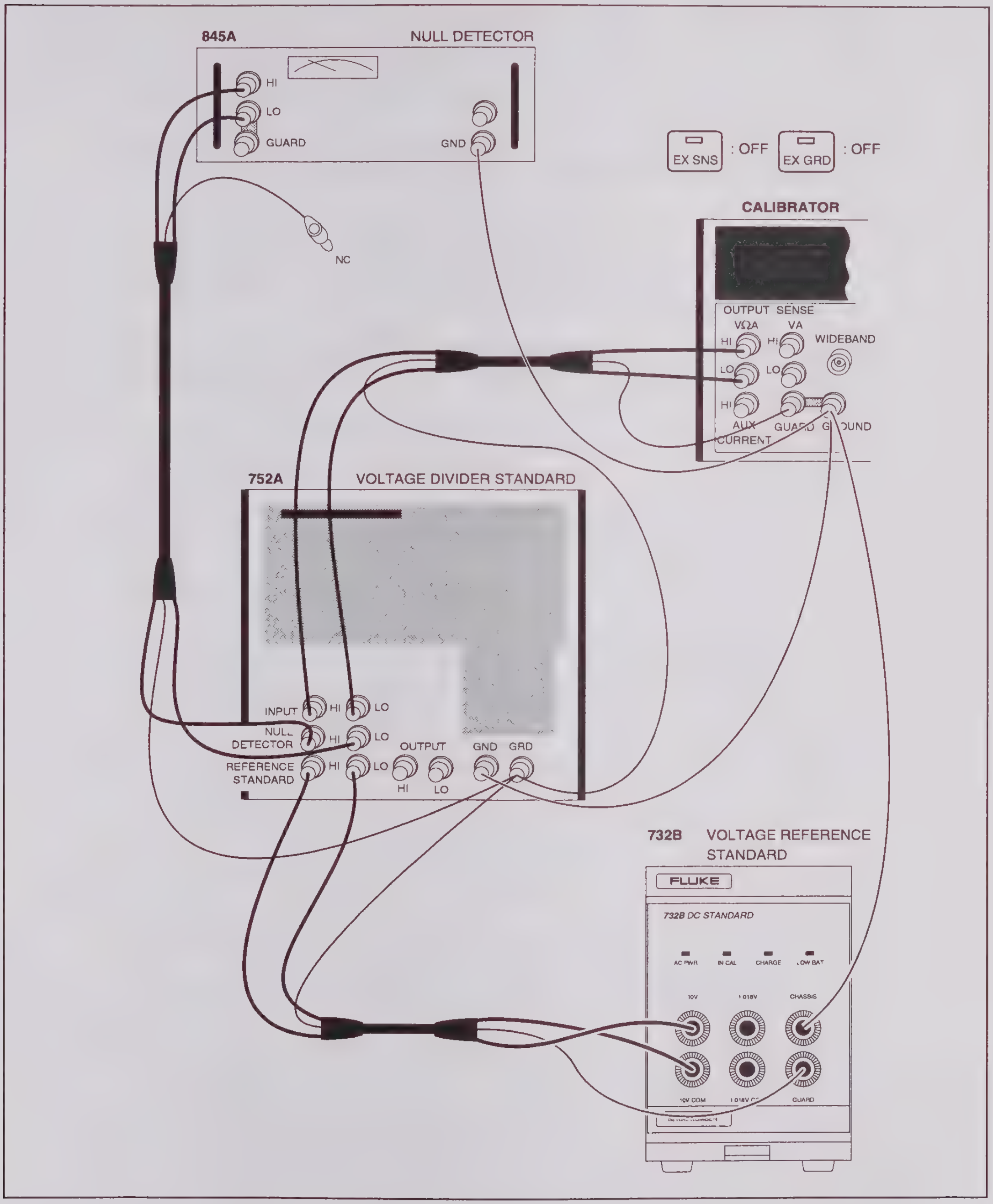


Figure 3-5. 220V DC Range Calibration Connections

Calibrating the Wideband AC Module (Option 5700A-03) 3-11.

The Wideband AC Module (Option 5700A-03) can be installed in either the 5720A or 5700A Series II calibrator. The module needs to be calibrated for both gain and flatness. The gain should be calibrated when the 5700A-03 main output functions undergo their routine calibration.

Since frequency flatness is determined by stable parameters (i.e. circuit geometry and dielectric constants), the flatness of the Wideband AC Module has excellent long-term stability. Consequently, a two-year calibration cycle is adequate for flatness calibration, and can be scheduled to coincide with the calibrator's shipment to a standards laboratory for periodic verification.

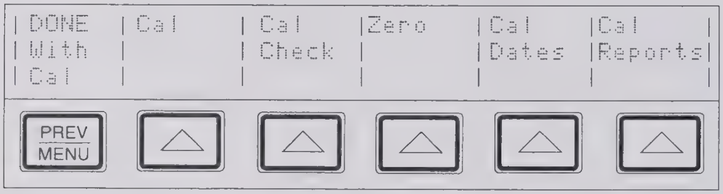
The following procedure describes how to perform the wideband gain calibration.

Note

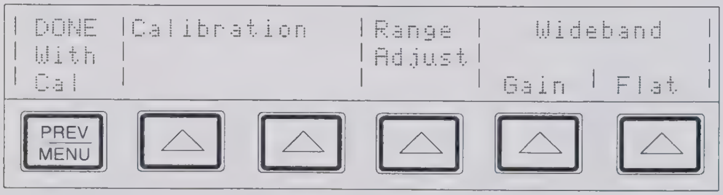
> *To perform this procedure you will need, in addition to the standard equipment supplied with the wideband option, a Type "N" female to double banana plug adapter (e.g., Pomona 1740).*

Before you start this procedure, make sure the calibrator is powered on and has completed an appropriate warm-up period. Then proceed with this procedure to calibrate the wideband gain.

1. Press the "Setup Menus" softkey; then press the "Cal" softkey to being up the menu shown below:



2. Press the "Cal " softkey to bring up the following menu:



3. Connect the wideband output cable between the WIDEBAND connector and the SENSE binding post.

   The center conductor of the 50Ω feedthrough should go to SENSE HI and shown in Figure 3-6. The GND tab on the adapter should be on the LO side.

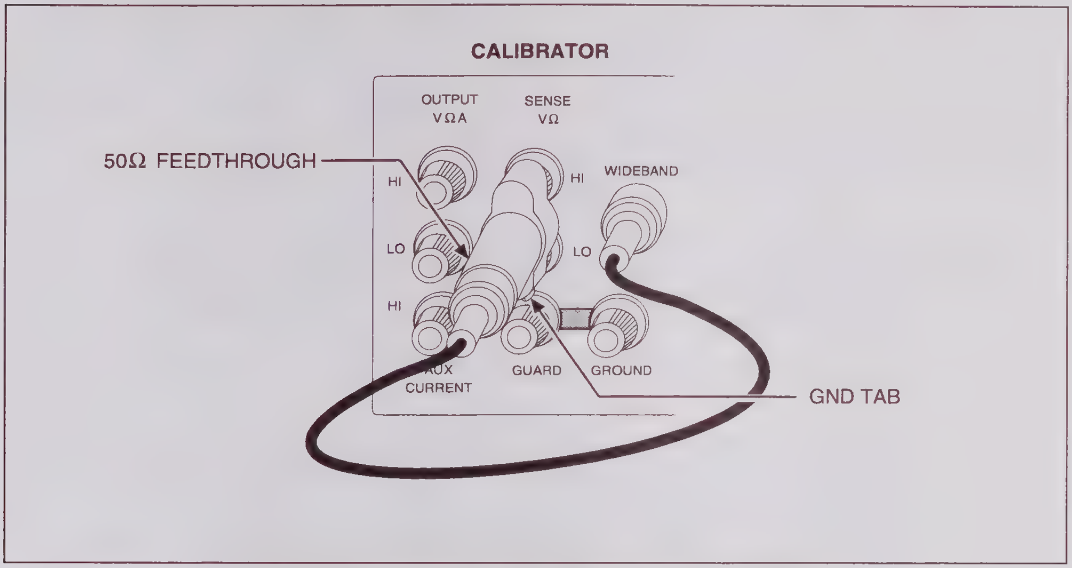
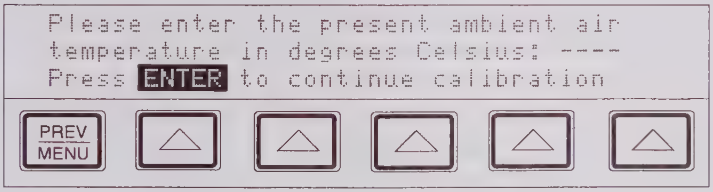


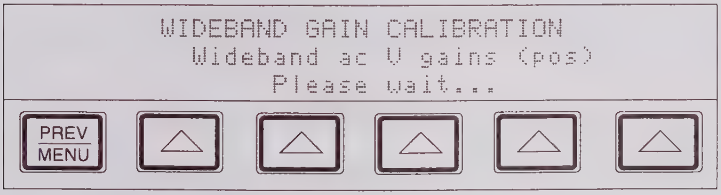
Figure 3-6. Wideband Module Calibration Connection

4. Press the “Gain” softkey to bring up the following display:



```
Please enter the present ambient air
temperature in degrees Celsius: ----
Press ENTER to continue calibration
```

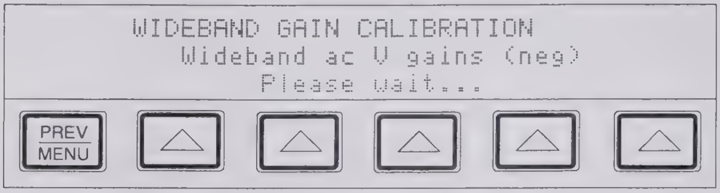
5. Enter the ambient temperature; the press ENTER. The display shows the following:



```
WIDEBAND GAIN CALIBRATION
Wideband ac V gains (pos)
Please wait...
```

As the wideband calibration proceeds, messages appear on the display identifying all processes as they are encountered. When positive gains calibration is complete, a message appears telling you to refer to the manual for negative gains connections.

6. Reverse the dual-banana connector so that the center connector is connected to LO; then press ENTER. The display shows the following:



```
WIDEBAND GAIN CALIBRATION
  Wideband ac V gains (neg)
     Please wait...
```

After a short time, a message appears indicating that the wideband calibration is complete.

7. To store the new constants, set the CALIBRATION switch to ENABLE and press “Store Values.” To discard the constants, press “DONE with Cal” and answer “YES” when the display asks for verification.
8. You have now completed the wideband gain calibration. Set the CALIBRATION switch to NORMAL, disconnect the wideband cable, and press RESET.

Performing a Calibration Check 3-12.

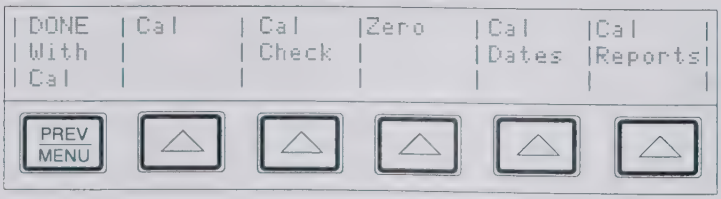
A calibration check is similar to the calibration, with the primary difference being that no changes are made to the stored constants, and the internal check standards are used as the reference points. A calibration check produces a report similar to the normal calibration report, and shows any proposed changes.

This procedure can be performed from an external computer, and can be set to run automatically, with no assistance (there is no need to enable the CALIBRATION switch, since no constants are changed).

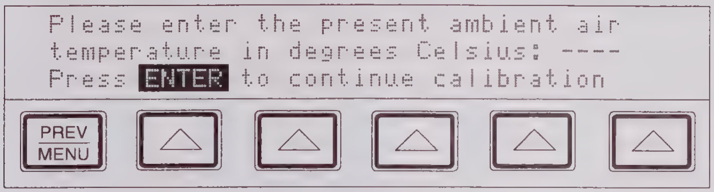
You can use the calibration check at any time to confirm the integrity of the calibrator without connecting external standards. The calibration check is also useful for collecting a performance history.

Before you begin this procedure, make sure the calibrator is powered on and has completed the appropriate warm-up period. Then follow this procedure to check the calibration.

1. Press the “Setup Menu” softkey; then press the “Cal” softkey to bring up the following menu:

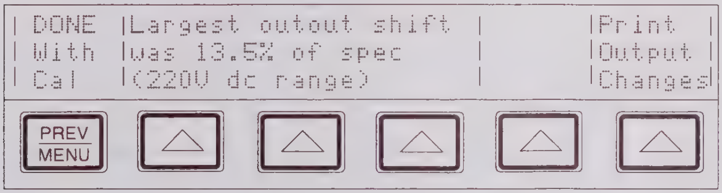


2. Press the “Cal Check” softkey to bring up the following display:



```
Please enter the present ambient air
temperature in degrees Celsius: ----
Press ENTER to continue calibration
```

3. Enter the ambient temperature; then press ENTER. As the calibration check proceeds, the display indicates the current process of the calibration check. When the check is complete, the largest shift that is detected appears on the display.



```
| DONE  |Largest outout shift  |          |Print  |
| With  |was 13.5% of spec     |          |Output |
| Cal   |(220V dc range)       |          |Changes|
```

4. You can now print a list of the proposed shifts, or quit without creating a list.

   To print the report, connect a printer and set up the serial interface as described in Chapter 6 of the *5700A/5720A Operators Manual*. Press the softkey under "Print Output Changes." To return to normal operation without printing, press the softkey under "DONE with check."

Press PREV MENU to exit the calibration menus.

Full Verification 3-13.

An independent external verification is recommended every two years, following normal periodic calibration or repair of the calibrator. Verification establishes and maintains parallel external traceability paths for the internal functions that are not adjusted or corrected during calibration. An example is the internal ac/dc transfer standard. Verification also serves as a check that internal calibration processes are in control.

Note

All performance limits specified in the test records apply to 90-day specifications for the Calibrator. If limits to other specifications are desired, the test records must be modified. A description of how to determine a guardband test limits is included in this section.

Note

Equivalent equipment and methods, either manual or automated, may be substituted for the following verification tests as long as the same points are tested, and equipment and standards used are at least as accurate as those specified. If standards are less accurate than specified, appropriate tolerance limit and/or accuracy reductions must be made to achieve equivalent results.

Not all of the procedures contained in this chapter need to be performed to verify your calibrator. This chapter contains the verification procedures for the 5720A and the 5700A Series II Calibrators. In addition, procedures are provided to verify the ac functions of the calibrator with wither a 5790A or a 792A. The following roadmap provides a high-level overview of the verification tests discussed in this chapter.

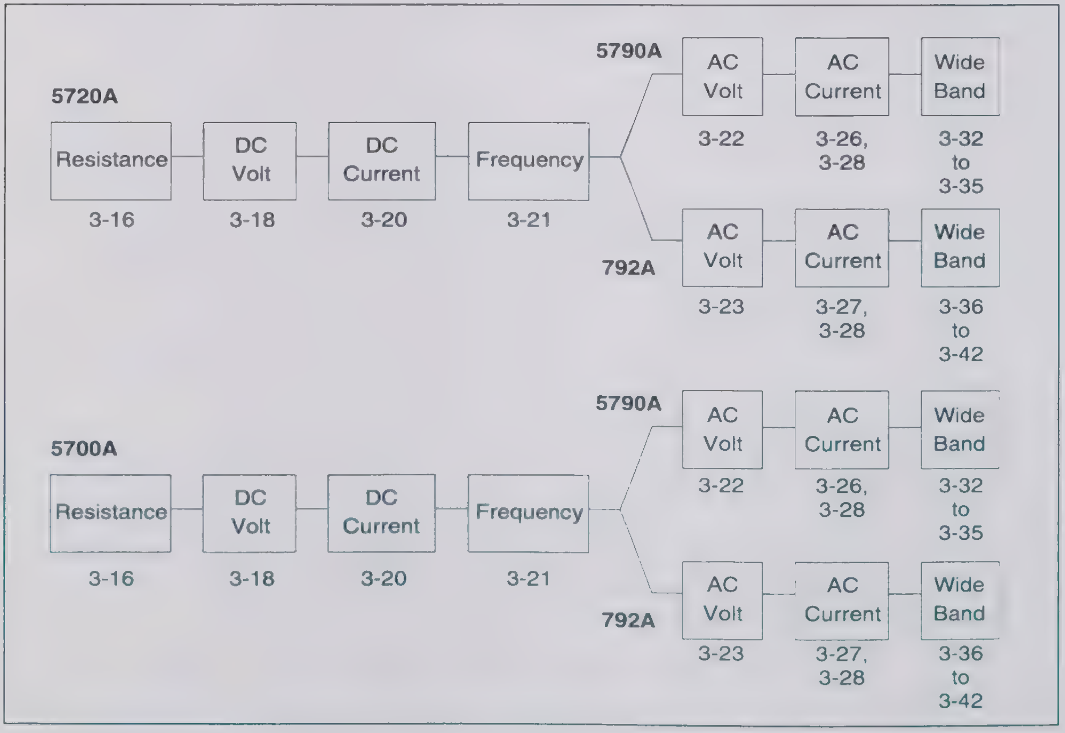


Figure 3-7. Overview of Verification Tests

In Figure 3-7, the location of each test is identified by the paragraph numbers.

Required Equipment for All Tests 3-14.

An abbreviated summary of required equipment for all the verification and optional tests is given in Table 3-2. Individual lists of required equipment are included at the beginning of each test. For substitution information, refer to Table 3-20, Minimum Use Requirements, located near the end of this section.

Warm-up Procedure for All Verification Tests 3-15.

Before performing verification, do the following preliminary steps:

1. Verify that the Calibrator has warmed up for at least thirty minutes.

   Note

   If the Calibrator has been powered off in an environment outside of operating environment specifications, particularly with humidity above 70%, allow a minimum of two hours warm-up. Extended storage at high temperatures and humidity may require up to four days of power-on stabilization.

2. If you are doing a regularly scheduled full verification as recommended by Fluke, calibrate the 5700A/5720A Series II as previously described before continuing with verification.
3. Ensure that each piece of external test equipment has satisfied its specified warm-up requirements.
4. Ensure that the Calibrator is in standby (STANDBY annunciation lit).

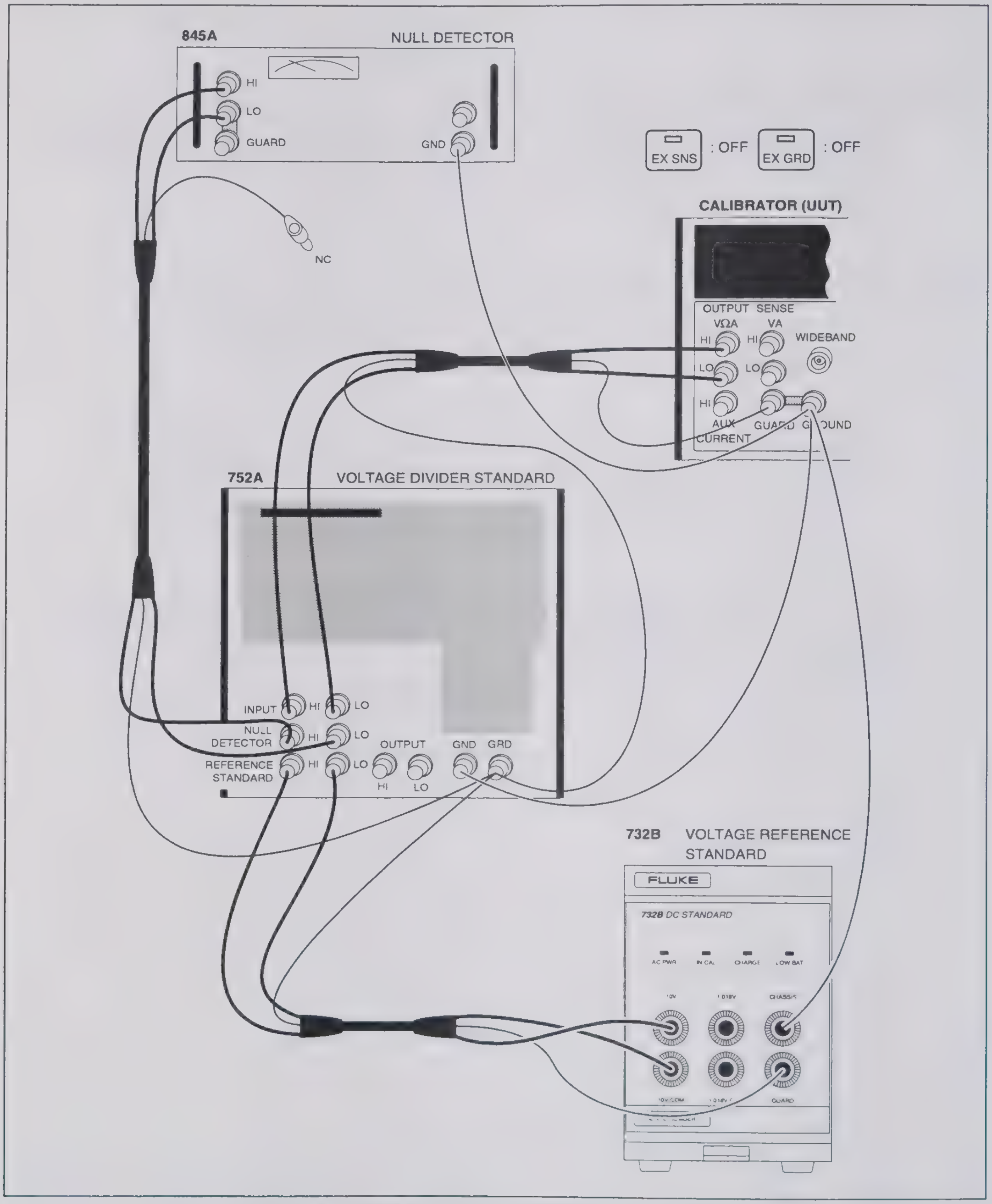


Figure 3-8. 220V DC Range Calibration Connections

Table 3-2. List of Required Equipment for Main Output

Equipment	Description	Application
AC Measurement Standard or AC/DC Transfer Standard	Fluke 5790A or 792A	ACV, ACI or ACV
Resistance Standards	Fluke 742A Series	Cal, Ohms, DCI
Reference Divider	Fluke 752A	DC V
Null Detector	Fluke 845A .	DC V
Shunt Adapter	Fluke 792A-7004	AC I
Calibrator	Fluke 5100B or 5500A	Ohms
Frequency Counter	Philips PM6669	Frequency
Shunts	Fluke A40 Series	AC I
High Current Shunt	Fluke Y5020	DC I
Resistance Standard	L&N 0.1Ω 4221B	DC I
DMM	Fluke 8505A or HP 3458	Ohms, DCI, ACI, AC V
Low Thermal Cables	Fluke 5440A-7002 (5700A) or 5440A-7003 (5720A or 5700A)	Various
Equipment Required for Wideband Ac Module (Option 5700-03) Verification		
Equipment	**Description**	**Application**
AC Measurement Standard	Fluke 5790A with Wideband Option -03	Wideband
Wideband Cable (supplied with 5700A-03)	Fluke Cable	Wideband
50Ω Termination (supplied with 5700A-03)	Fluke Termination	Wideband
Adapter (supplied with 5700A-03)	Pomona 1269 BNC(F) to dual banana plug	Wideband
Adapter	Kings KN-99-46 N(F) to BNC(M)	Wideband
Equipment Required for Optional Tests		
Equipment	**Description**	**Application**
Oscilloscope Mainframe	Tektronix 7000 Series	HF Noise
Differential Amplifier	Tektronix 7A22	HF Noise
Distortion Analyzer	HP 334A	AC V, ACI, Distortion
Spectrum Analyzer	HP 8590A	AC V, Wideband Distortion
Kelvin Varley	Fluke 720A	DC V Linearity

Resistance Verification Test 3-16.

The following test requires testing at the high, low and intermediate values only. This is because the 5700A/5720A Series II creates the other values of resistance from these values. Use Tables 3-21 (5720A) and 3-22 (5700A) for test records. For the convenience of anyone wishing to test the intermediate values, the tolerance limits are included. Testing these values could be done using a Hamon-type ratio device and a very stable, high-resolution bridge or DMM, or a combination of the two. Table 3-3 lists equipment required for this test. See Table 3-20, Minimum Use Requirements, for substitution information.

Table 3-3. Equipment Required for Resistance Testing

EQUIPMENT	DESCRIPTION
Resistance Standards	Fluke 742A Series in the following values: 1Ω, 1.9Ω, 10Ω, 10 kΩ, 19 kΩ, 10 MΩ, and 19 MΩ
Current Source	Fluke 5100B, 5500A, or EDC CR103/J
DMM	Fluke 8505A or HP 3458

1. Connect the equipment as shown in Figure 3-5.
2. Set the Calibrator output to 1Ω with external sensing (EX SENS indicator lit) and set the dc DMM to read dc V. Record the 1Ω resistance standard value on the test record as the 1Ω STD RES VALUE.
3. Multiply the certified value of the 1Ω resistance standard by 0.1 and record the result on the test record as the 1Ω STD VOLTAGE.
4. Connect the DMM across the sense terminals of the 1Ω resistance standard.
5. Set the direct current source for a nominal 100 mA output. Vary the source until the DMM reading is as close as possible to the 1Ω Standard Voltage recorded in the previous step. Record the DMM voltage reading on the test record as the MEASURED 1Ω STD VOLTAGE.

Note

If the current source used has the resolution to achieve a voltage reading to within ±5 ppm of the value in step 3, it is not necessary to calculate the cal current in take next step. In this case, when you come to step 9 you will simply multiply the voltage reading from step 9 by a factor of 10, which is the same as dividing by 100 mA (0.1A).

6. Calculate the exact current by dividing the MEASURED 1Ω STD VOLTAGE by the 1Ω STD RES VALUE; record the result on the test record as the CAL CURRENT.
7. Enter the Calibrator displayed 1Ω value on the test record as the UUT 1Ω DISPLAYED VALUE.
8. Transfer the dc DMM leads to the Calibrator sense terminals.
9. Enter the DMM voltage reading on the test record as the UUT 1Ω VOLTAGE.
10. Calculate the UUT true 1Ω resistance by dividing the UUT 1Ω VOLTAGE by the CAL CURRENT.
11. Adjust the output adjustment knob for a UUT Control Display reading equal to the true 1Ω resistance value calculated in the previous step. The error from the displayed value is also shown on the Control Display. Enter the value of the error on the test record as the UUT DEVIATION FROM DISPLAYED VALUE.

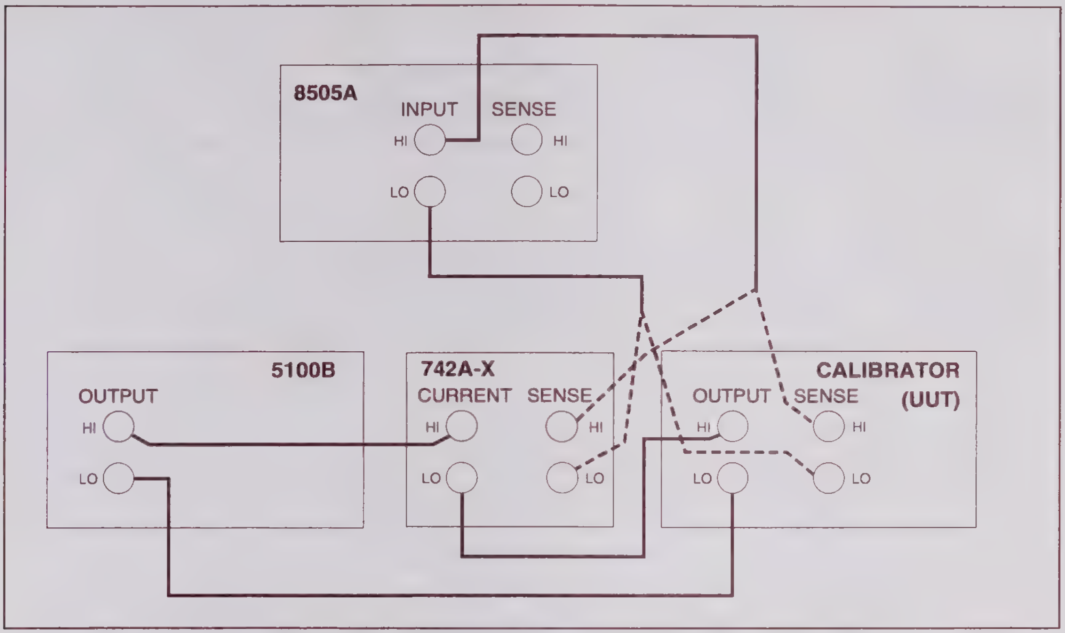


Figure 3-9. 1 Ohm and 10 Ohm Resistor Verification

Note

There is no need to do the cal current calculation of step 6 if the current source has a settability of ±3 ppm.

12. Repeat steps 3 through 11 for the 1.9Ω and 10Ω resistance values using the 1.9Ω and 10Ω resistance standards. At the 10 ohm check, use 10 mA of current and a multiplier for step 3 of 0.01.
13. The low-value (1Ω, 1.9Ω, and 10Ω) tests are summarized in Table 3-4.

Table 3-4. Low Value Resistance Calibration Using a Current Source

5720A (UUT) Resistance	Apply Current	5720A Deviation From Displayed Value (90-day)	5720A Displayed Value
1Ω	100 mA	±95 ppm	0.9995 to 1.0005
1.9Ω	100 mA	±95 ppm	1.89905 to 1.90095
10Ω	10 mA	±25.0 ppm	9.997 to 10.003
5700A (UUT) Resistance	**Apply Current**	**5700A Deviation From Displayed Value (90-day)**	**5700A Displayed Value**
1Ω	100 mA	±95 ppm	0.9995 to 1.0005
1.9Ω	100 mA	±95 ppm	1.89905 to 1.90095
10Ω	10 mA	±28.0 ppm	9.997 to 10.003

14. For the remaining tests, no current source is required. Verify that each true UUT value is within the limits shown in Table 3-5.
    a. Connect the DMM, set for 4-wire resistance, first to the Resistance Standard equal to the UUT nominal output and then to the UUT itself. In each case, record the resistance standard DMM reading and the resistance standard certified value.
    b. Calculate the DMM correction by subtracting the DMM reading from the certified value; enter this calculated value on the test record as DMM ERROR.
    c. Move the DMM to the UUT terminals; enter the DMM reading on the test record as DMM UUT RES RDG.
    d. Algebraically add the DMM ERROR and the DMM UUT RES RDG; enter the sum on the test record as UUT TRUE RES VALUE.
    e. Adjust the output adjustment knob for a UUT Control Display reading equal to the true resistance value previously calculated. The error from the displayed value is also shown on the Control Display. Enter this error (with polarity reversed) on the test record as the UUT DEVIATION FROM DISPLAYED VALUE.

Two-Wire Compensation Verification *3-17.*

Use the following steps to verify that two-wire compensation operates correctly:

1. Connect the UUT (output set to 100Ω, with external sensing) to the DMM (set for 4-wire resistance measurement). Note the DMM reading.
2. Connect two shorts: DMM SOURCE HI to SENSE HI and DMM SOURCE LO to SENSE LO.
3. Activate UUT 2-wire compensation.
4. Check that the DMM reading returns to within 4 miliohms of the reading noted in step 1.

DC Voltage Verification Test 3-18.

The following test checks every dc voltage range by testing the output accuracy at decade values of voltage from 100 mV to 1000V. Use Table 3-23 (5720A) or Table 3-24 (5700) for the test record. Table 3-5 lists equipment required for this test as well as the Linearity Test that follows. See Table 3-20, Minimum Use Requirements, for equipment substitution information.

Table 3-5. Equipment Required for DC Voltage Testing

EQUIPMENT	MODEL
DC Reference Standard	Fluke 732A
Reference Divider	Fluke 752A
Null Detector	Fluke 845A (B or R)
Low Thermal Cables	5440A-7002
	5440A-7003

Note

The 5440A-7002 and 5440A-7003 is for the 5700A; the 5720A uses only the 5440A-7003.

Proceed as follows to perform the dc voltage verification test:

1. Self-calibrate the reference divider in accordance with its instruction manual prior to preceding.
2. Connect the equipment as shown in Figure 3-9.
3. Set the reference divider to 0.1V. Set the Calibrator to the certified value of the dc reference standard divided by 100. For example, if the certified value of the dc reference standard is 10.000007V, set the Calibrator to 100.00007 mV.
4. Press OPR/STBY. After the reading has settled, verify that the null detector reads 0V ±1.20 μV (5720A 90-day specification) or 0V ±1.45 μV (5700A 90-day specification). Set the Calibrator to standby.
5. Repeat the above process to test each dc voltage range output listed in Tables 3-23 or 3-24. (0.1V is in the table for completeness; you do not need to repeat it.) After the null detector reading stabilizes, ensure that any observed meter rattle (over and above the null detector rattle in the "zero" position) over a ten-second period does not exceed the amount shown in the last column. In each case, set the 5720A to standby before changing to the next voltage settings and go back to operate before reading the null detector.
6. Reverse the connections of the dc reference standard at the reference divider and repeat the previous measurement process for the -0.1V, -1V and -10V outputs.

DC Voltage One-Tenth Scale Linearity Test 3-19.

Note

If the result of the previous test at 1V on the 11V range was less than 2.5 µV it is not necessary to perform this test.

This test uses the same equipment as the previous test. Proceed as follows to perform the DC Voltage One-Tenth Scale Linearity Test:

1. Set the reference divider range to 10V. On the voltage reference standard, remove the lead from the 10V high terminal and connect it under the binding post of the low terminal along with the low lead to provide a 0V reference input to the reference divider. Set the Calibrator output for 10V, then activate range lock for the 11V range. Now set the Calibrator to 0V OPERATE.
2. Note the reading on the null detector. Press OFFSET on the Calibrator. Return the lead on the voltage reference to the high output terminal.
3. Set the Calibrator to 10V. Use the Calibrator output adjustment knob to obtain the reading previously noted on the null detector. Press SCALE on the Calibrator.
4. Set the Calibrator to 1V dc. Set the reference divider to the 1V range, and verify that the null detector indicates less than 2.5 µV from the noted reading.
5. Press RESET on the Calibrator. This completes the DC Voltage Calibration Verification testing.

Direct Current Accuracy Verification Test 3-20.

Equipment required for the Direct Current Accuracy Verification Test is listed in Table 3-6. Proceed as follows to test accuracy of the dc current function:

Table 3-6. Equipment Required for Direct Current Test

EQUIPMENT	MODEL
DC DMM, 6-1/2 digit	Fluke 8505A or HP 3458
High-Current Shunt	Fluke Y5020 (for 5725A only)
Resistance Standards	L&N 4221B (0.1Ω at 2A) Fluke 742A-1 (1Ω at 200 mA) Fluke 742A-10 (10Ω at 20 mA) Fluke 742A-1k (1 kΩ at 2 mA) Fluke 742A-10k (10 kΩ at 200 μA)

Use Table 3-25 (5720A) and Table 3-26 (5700A) for the test records.

1. Connect the dc DMM to the Calibrator output and set the Calibrator for outputs of 200 mV, -200 mV, 2V, and -2V, and record the dc DMM reading at each voltage in Table 3-25 or 3-26.

2. Refer to the resistance standard test report and enter the corrections for all the certified values in ± ppm in column A on the test record.

Note

The STD RES CORRECTION is the difference between the nominal standard resistor value and the certified or true resistor value. For example, if the nominal value is 0.1Ω and the certified value is 0.0999963Ω, the difference equals 0.0000037Ω, or +37 ppm.

3. Connect the equipment as shown in Figure 3-10 using the L&N 0.1Ω resistor.
4. Set the Calibrator for a 2A dc output, and adjust the Calibrator using the output adjustment knob to obtain the characterized voltage reading on the dc DMM. Wait 3 seconds, and record the Calibrator error display reading in ± ppm (Column B).

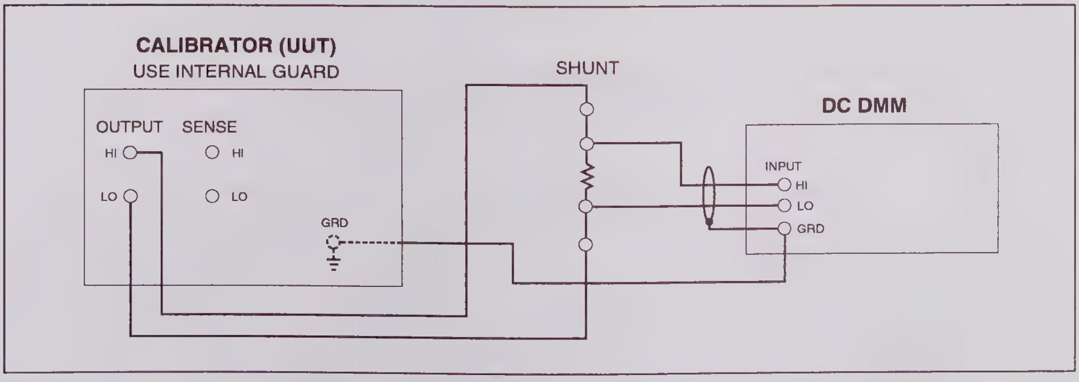


Figure 3-10. Direct Current Accuracy Test Setup

5. Algebraically add column B to column A. Enter the result on the test record. Verify that it is within the test limits shown.
6. Repeat steps 2 through 5 using the Fluke 742A Resistance Standards and Calibrator output currents shown in Tables 3-25 or 3-26.
7. If the Calibrator is attached to a 5725A Amplifier, connect the Y5020 shunt to the 5725A output terminals. Connect the dc DMM to the Y5020 voltage output connector.
8. Set the Calibrator to 10A, -10A, 5A, 3A and -3A and record the dc DMM readings on the 5725A Amplifier dc current test record. Divide these readings by the certified value of the Y5020, record the resultant current and verify that it is within the test limit shown.

AC Voltage Frequency Accuracy Test *3-21.*

This test requires the use of a frequency counter. Philips model PM6669 is recommended. Use Table 3-27 for the test record. When using Philips Model PM 6666, it is recommended to use a 1 MHz Low Pass Filter as shown in Figure 3-11. Refer to Table 3-20, Minimum Use Requirements, for substitution information.

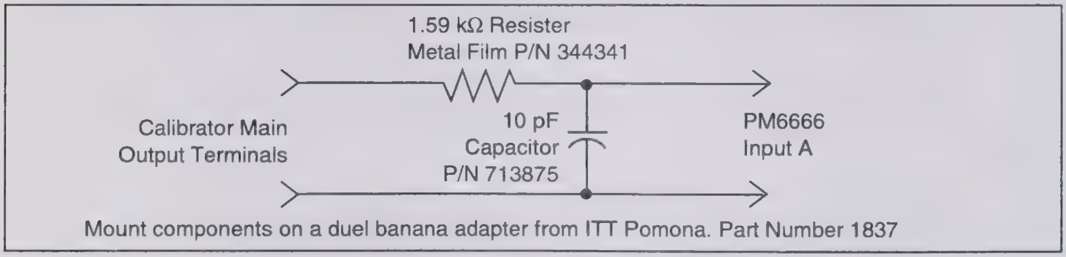


Figure 3-11. 1 MHz Low Pass Filter

To check the Calibrator frequency accuracy, proceed as follows:

1. Connect the frequency counter to the output terminals of the Calibrator.
2. Set the Calibrator to 1V at the output frequencies listed in Table 3-27. Verify that the counter reads within the limits shown on the test record.
3. Disconnect the counter from the Calibrator.

Output Level Tests For AC V Ranges (5790A) *3-22.*

This test requires the use of equipment listed in Table 3-7.

Table 3-7. Equipment Required for AC V Output Level Tests

Equipment	Model
AC Measurement Standard	Fluke 5790A
BNC(F) to Dual-Banana Plug Adapter (2 required)	Pomona 1269
Coax Cable - RG-58A/U or RG-58C/U with BNC(M) Connectors, 12 ± 1 inch Long	

Use Table 3-28 (5720A) or Table 3-29 (5700A) for the test records.

1. Place the 5790A on top of the Calibrator and connect the equipment as shown in Figure 3-12.

Note

The point of measurement is at the end of the cable and adapter that connects to the 5790A. Other cable lengths and adapters will yield different results at high frequencies.

2. On the 5790A push UTIL MENUS button and then the MEAS CONTROL softkey. Set the digital filter mode to FAST and the restart to MEDIUM. Push the DONE soft key twice to return to the measurement display.
3. Set the 5790A to 2 mV at 1 kHz. Adjust the Calibrator using the output adjustment knob for a reading of 2.0000 mV ±1 count on the 5790A. Record the Calibrator error display reading in the 90 Day column in Table 3-28 (5720A) or 3-29 (5700A) as appropriate for the verification interval.
4. Verify that the result is within the test limits.
5. Repeat the previous steps for the 2 mV output on all remaining frequencies on the test record.
6. Proceed to the remaining output levels and frequencies list in Table 3-28 or 3-29 and repeat steps 3 through 5 using the appropriate output level in each step, and the adjustment tolerance in Table 3-8.

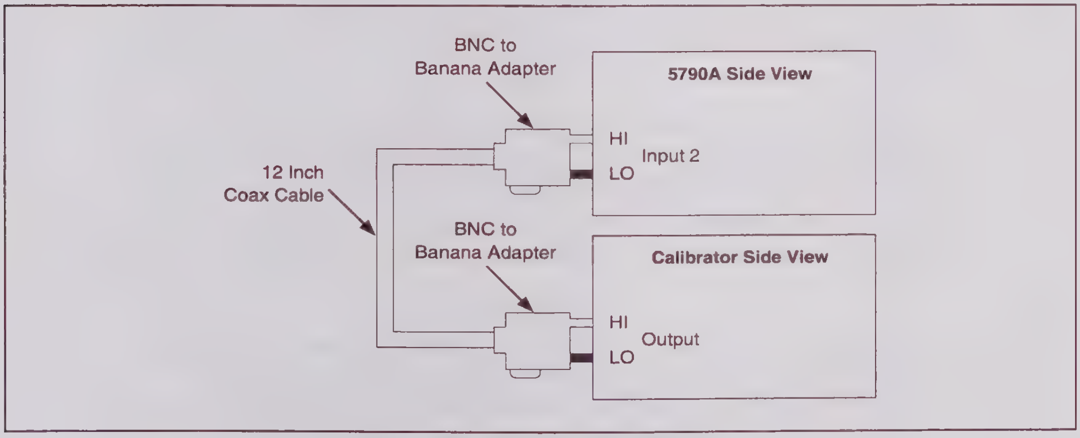


Figure 3-12. AC Voltage Test Setup

Table 3-8. 5790A Adjustment Counts

5700A/5720A Series II Output Level	5790A Display	5790A Adjustment Counts*
2 mV	2.0000	±1
20 mV	20.0000	±1
200 mV	200.0000	±4
2V	2.000000	±4
2.3V	2.30000	±1
20V	20.00000	±4
200V	200.0000	±4
300V	300.000	±1
600V	600.000	±2
1000V	1000.000	±2
*Adjustment counts of 3 times the listed value is allowed at 1 MHz		

Output Level Tests For AC V Ranges (792A) 3-23.

This test requires the use of equipment listed in Table 3-9. Use Table 3-30 (5720A) or Table 3-31 (5700A) for test records.

Table 3-9. Equipment Required for AC V Output Level Tests

Equipment	Model
AC/DC Transfer Standard	Fluke 792A
DMM	Fluke 8505A
Type "N" to Dual-Banana Plug Adapter	Pomona 1740

Note

Before beginning this test, refer to the Table of AC/DC Differences for the 792A Transfer Standard. Enter the transfer standard corrections for ac/dc difference for each level and frequency on to the test record.

1. Connect the equipment as shown in Figure 3-12. Connect the transfer standard directly to the output of the Calibrator using a Type "N" to male banana adapter.

Caution

Make sure the correct 792A range is selected before applying voltage to the 792A. Inputs to the 792A that exceed the protection level printed on its rear panel may disrupt the state of calibration and damage the transfer standard.

2. Turn on the 792A Power Pack and set the 792A to the 2.2V range.
3. Set the Calibrator to 2V dc, internal sense, and operate.
4. Allow at least 30 seconds for the 792A to stabilize, then zero the DMM connected to the 792A using the DMM offset function.
5. Set the Calibrator output to -2V. Adjust for any reversal error using the Calibrator output adjustment knob and storing a new offset for equal offset for +2V and -2V. For example, if the offset when switching to-2V is +0.00004, store a new offset so that at +2V the DMM reads +0.00002 and at -2V the DMM reads -0.00002. Note: If you desire, you can produce the same result using the scaling function of the DMM instead of the Calibrator offset function.

6. Set the Calibrator to 2V at 1 kHz. Adjust the Calibrator output using the output adjustment knob for a null (0.00000V) on the DMM. Record the Calibrator error display reading on the test record. Algebraically add the Calibrator error display reading to the previously entered transfer standard ac/dc difference, if any, and verify that the result is within the test limits shown in the test record.
7. Set the Calibrator output to +2V dc. Verify that the DMM offset reading returns to within ±5 ppm of the stored offset in step 5. If it does not, repeat steps 4 through 6 until the required result is achieved.

Note

For the remaining frequencies above 1 kHz this test uses a ac/ac transfer technique rather than ac/dc. This test references every frequency back to 1 kHz.

8. Set the Calibrator to 2V at 1 kHz and zero the DMM using its offset function.
9. Refer to the test record (Table 3-30 or 3-31) Set the Calibrator to the next frequency point to be tested. Adjust the Calibrator using the output adjustment knob for a null on the DMM and record the Calibrator error display reading on the test record. Algebraically add the error display reading to the recorded transfer standard ac/dc difference and to any noted error display reading at 1 kHz measured in step 6. Verify the result is within test limits.
10. Repeat the previous step for all remaining frequencies on the test record.
11. Repeat this procedure at the 20 V, 200 mV, 20 mV and 200V ranges. At all voltages be sure the 792A RANGE SELECT switch is set to the appropriate range before applying voltage. At voltages above 200V for the 792A, use the 1000V range resistor and set the 792A to 2.2V. Refer to Figure 3-13 for connections.

Note

If a direct measuring transfer standard is not available for the 20 mV and 200 mV ranges, use the Alternate Procedure For 20 mV and 200 mV Verification following the Optional Tests near the end of this chapter.

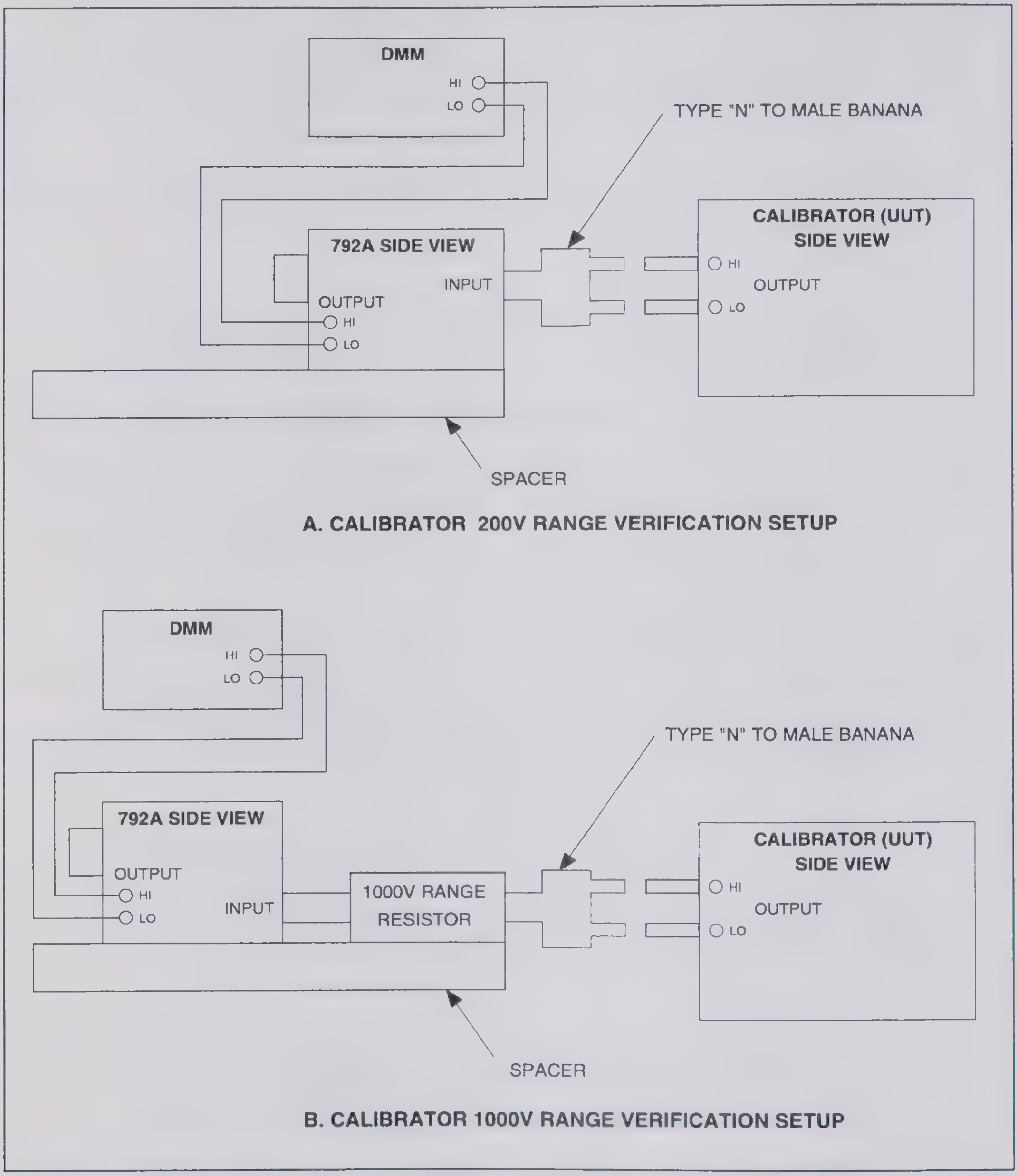


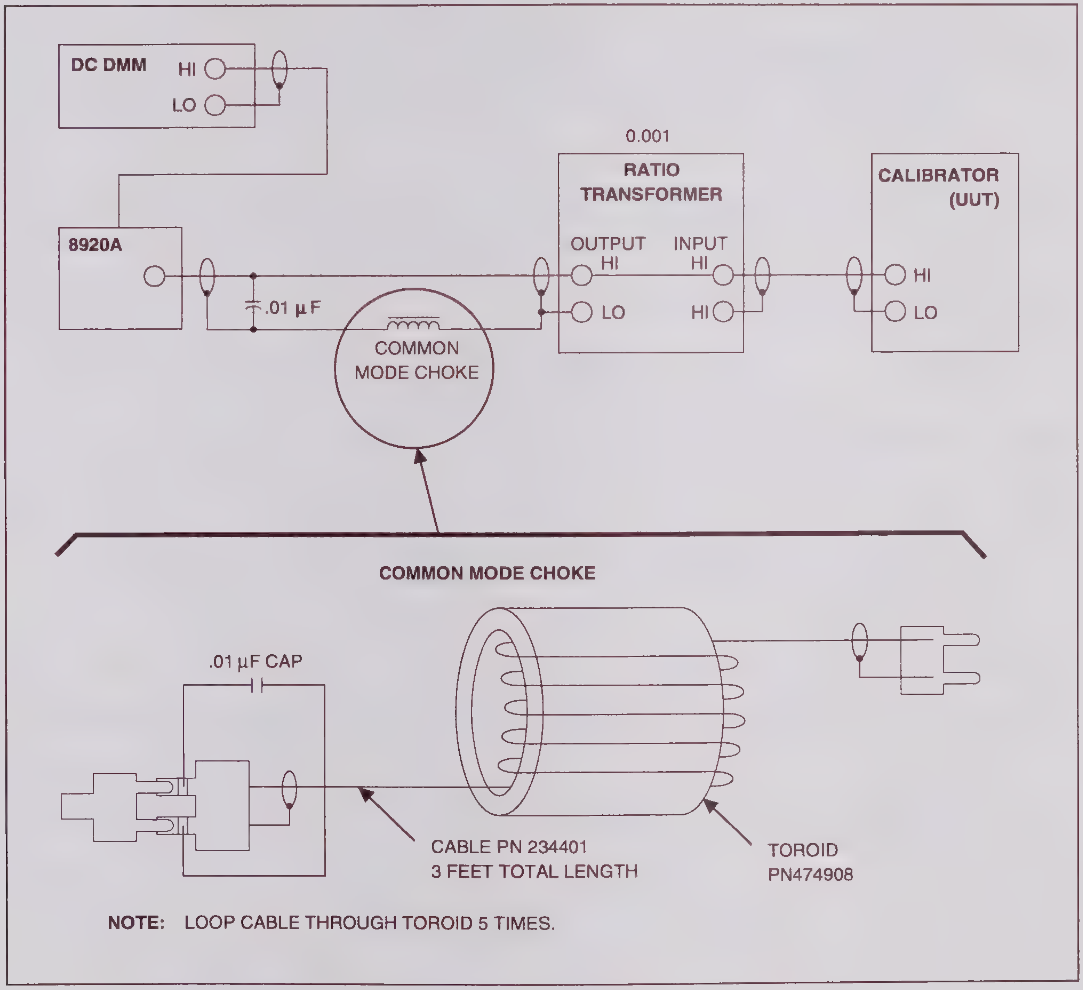
Figure 3-13. AC Voltage Test Setup (792A)

AC Voltage 2 mV Range Output Level Test (792A) 3-24.

The 2 mV ac range is generated by the same 1000:1 divider, and it uses the same signal path as used to generate the 20 mV range. The difference being the Oscillator assembly is switched from the 20V range to the 2V range. Since the 2V range and 20 mV range have been previously verified for absolute uncertainty and flatness, you can verify the 2 mV range by making an absolute check at 1 kHz. It is not necessary to check the flatness of the 2 mV range, but if a flatness check is desired, refer to Optional Tests.

This test uses the previously measured Calibrator 2V range and a ratio transformer to establish an absolute 1.9 mV level at 1 kHz on a rms wideband voltmeter/dc DMM combination. These meters function as a transfer device in measuring the accuracy of the 2 mV range.

To eliminate hf noise errors in this measurement, use a common-mode choke and a filter capacitor. The capacitor should be a 0.01 µF. Figure 3-14 shows how to build the common-mode choke.



NOTE: LOOP CABLE THROUGH TOROID 5 TIMES.

Figure 3-14. 2 mV Range Absolute Level Verification (792A)

Absolute Level Verification of 2 mV Range At 1 kHz. (792A) 3-25.

Use Table 3-32 for a test record. Proceed as follows to verify the absolute level of the 2 mV ac voltage range at 1 kHz:

1. Connect the equipment as shown in Figure 3-14.
2. Set the Calibrator output to 1.9V at 1 kHz. Using the output adjustment knob, adjust the output for an error display reading that is the same as the calculated error for 2V, 1 kHz in Table 3-30 or 3-31, Output Level Tests for AC Voltage Ranges 20 mV.
3. Set the ratio transformer to 0.001 and record the reading of the dc DMM as the CHARACTERIZED 1.9 mV READING on the test record (Table 3-32.).

4. Disconnect the ratio transformer from the setup. Set the Calibrator to 1.9 mV at 1 kHz and connect the rms voltmeter/dc DMM combination to the output of the Calibrator. The common mode choke and filter capacitor must remain in place. Adjust the Calibrator output using the output adjustment knob until the dc DMM reads the same as recorded in the previous step. Record the Calibrator error display reading on the test record and verify that it is within the limits shown.

AC Current Test, 22 mA to 11A Ranges (5790A) 3-26.

This test requires the use of equipment listed in Table 3-10, when using the 5790A Input 1 or the equipment listed in Table 3-11, when using the 5790A Shunt Input. Use Tables 3-33 (5720A) or 3-34 (5700A) for a test record.

Table 3-10. Equipment Required for 22 mA to 11A Alternating Current Test Using the 5790A Input 1

Equipment	Model or Description
AC Measurement standard	Fluke 5790A
Current Shunts	Fluke A40 Series: 20 mA, 200 mA, 2A, and A40A Series: 10A (if verifying a 5725A) , with AC-DC difference corrections.
Current Shunt Adapter	Fluke 792A-7004 A40 current shunt adapter
Cable	Pomona 1368-A-18. Double banana to single banana plugs.
Cable (For 10A Setup)	Pomona 5268-C-12. BNC(M) to single banana plugs.
Cable (For 10A Setup)	Fluke A45-4003 (PN 212853) UHF(M) to UHF(M) with RG8A/U cable
Adapter (For 10A Setup)	Pomona Model 1707. UHF(F) to banana adapter.
Adapter (For 10A Setup)	Kings KC-99-34 UHF(M) to BNC(F)

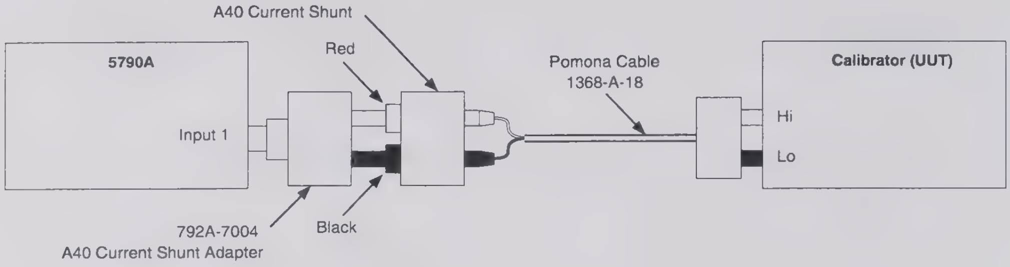
Table 3-11. Equipment Required for 22 mA to 11A Alternating Current Test Using The 5790A Shunt Input

Equipment	Model or Description
AC Measurement standard	Fluke 5790A
Current Shunts	Fluke A40 Series: 20 mA, 200 mA, 2A, and A40A Series: 10A (if verifying a 5725A) , with AC-DC difference corrections.
Current Shunt Adapter	Fluke 5790A-7001 A40 and A40A Current Shunt Adapter
Cable	Fluke (PN 877048) Supplied with the 5790A-7001 Shunt Adapter. UHF (M) to Dual Banana (M).
Cable	Pomona 1368-A-18. Double banana to single banana plugs.
Cable (For 10A Setup)	Fluke A45-4003 (PN 212852). UHF(M) to UHF(M) with RG8A/U cable
Adapter (For 10A Setup)	Pomona Model 1707. UHF(F) to banana adapter.

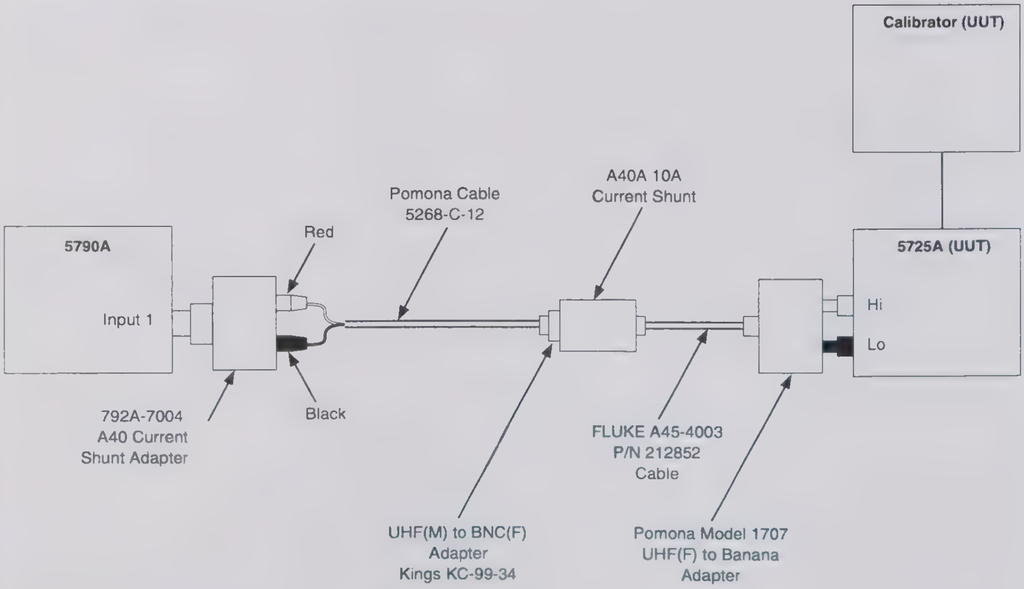
1. Connect the equipment as shown in Figure 3-15(A) if you are using the 5790A Input 1 or Figure 3-15(C) if you are using the 5790A Shunt Input. Use the 2A shunt.
2. Enter the ac to dc difference corrections for each shunt at each frequency in the appropriate column of the test record (Table 3-33 or 3-34).
3. Set the Calibrator for a +2A dc output. Adjust the output so that the error display is equal to the UUT actual error for a +2A output, as shown on the dc current test record in Table 3-25 (5720A) or Table 3-26 (5700A).
4. Push the INPUT 1 button on the 5790A if you are using the INPUT 1 setup, or the SHUNT button if you are using the SHUNT set up. Let the 5790A settle on a reading.
5. Push the SET REF soft key on the 5790A.
6. Set the Calibrator for a -2A dc output. Adjust the output so that the error display is equal to the UUT actual error for a -2A output, as shown in Table 3-25 (5720A) or Table 3-26 (5700A).
7. Press the AVG REF soft key on the 5790A after the 5790A reading settles.
8. Set the Calibrator to 2A at 40 Hz and OPERATE.
9. Record the error displayed on the 5790A in Table 3-33 or 3-34.
10. Return to the error corrected +2A DC output that was set in step 3 and verify that the 5790A display returns to a zero reading ±10PPM. If necessary, repeat steps 3 through 9 until the required results are obtained.
11. Algebraically add the 5790A error display reading to the A40 Shunt ac to dc difference, and verify that the result is within the specifications of the test limits. Record the results on Table 3-25 (5720A) or Table 3-26 (5700A).
12. Change the Calibrator frequency to 1 kHz, 5 kHz and 10 kHz. At each frequency record the 5790A error display. Verify the results as was done in steps 8 and 9.
13. Repeat steps 3 through 12 at currents of 200 mA and 20 mA using the appropriate A40 current shunt at the frequencies shown on the test record (Table 3-33 or 3-34).
14. For units with a 5725A Amplifier attached, use the test set up shown in Figure 3-15(B) or Figure 3-15(D) using the 10A shunt at the frequencies listed on the test record.

Note

When verifying the 5725A Amplifier at the 10A level, allow sufficient time for the A40A-10 shunt to reach thermal stability after initially applying the current.

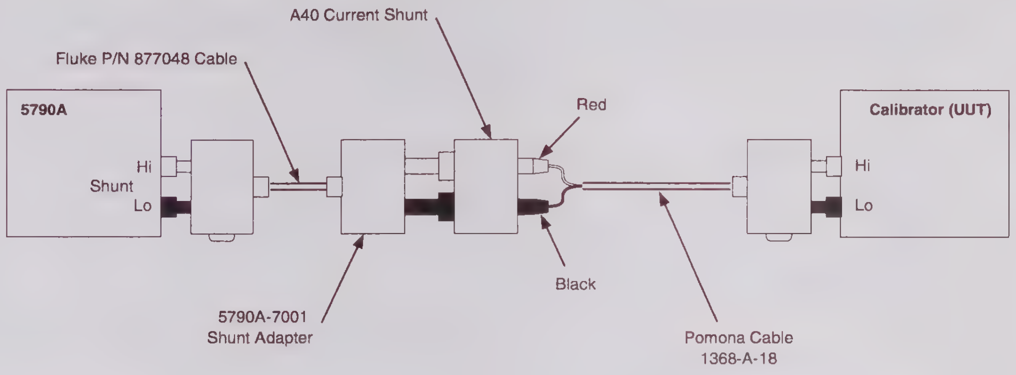


A. Alternating Current Test Setup, 22 mA to 2A Using 5790A Input 1

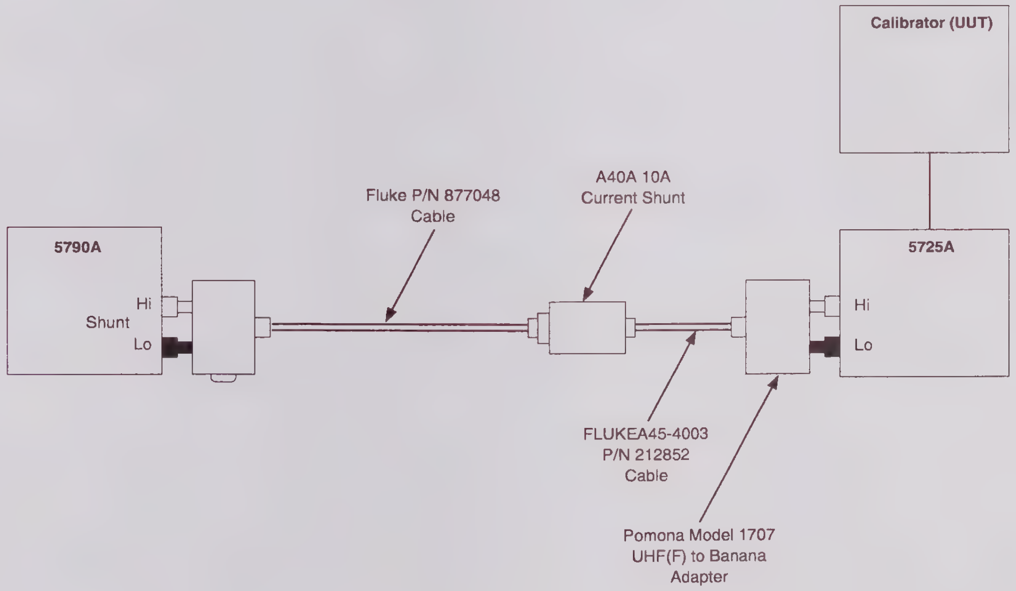


B. Alternating Current Test Setup, 10A Using 5790A Input 1

Figure 3-15. Alternating Current Test Setup (5790A)



C. Alternating Current Test Setup, 22 mA to 2A Using 5790A Shunt Input



D. Alternating Current Test Setup, 10A Using 5790A Shunt Input

Figure 3-15. Alternating Current Test Setup (5790A) (cont)

AC Current Test, 22 mA to 11A Ranges (792A) *3-27.*

Equipment required for the Alternating Current Accuracy Verification Test is listed in Table 3-12. Use Table 3-35 (5720A) or Table 3-36 (5700A) for a test record. Proceed as follows to test the accuracy of the ac current function:

Table 3-12. Equipment Required for Alternating Current Test

Equipment	Model or Description
Shunt Adapter	Fluke 792A-7004
AC/DC Transfer Standard	Fluke 792A
Current Shunts	Fluke A40 Series: 20 mA, 200 mA, 2A, and 10A with AC-DC difference corrections
DMM	Fluke 8505A
T9 Metal-Film Resistors	200Ω and 2 kΩ values, securely mounted in a dual banana plug

1. Enter the ac to dc difference corrections for each shunt at each frequency in the appropriate column of the test record (Table 3-35 or 3-36).
2. Connect the equipment as shown in Figure 3-16. Use the 2A Current shunt.
3. Set the Calibrator for a +2A dc output. Adjust the output so that the error display is equal to the UUT actual error for a +2A output, as shown on the dc current test record in Table 3-25 (5720A) or Table 3-26 (5700A).
4. Allow sufficient time (usually around 10 minutes for the first reading) for the transfer standard null meter reading to stabilize. Adjust the transfer standard null controls for a precise null indication.
5. Proceed as follows to obtain an average of the reversed dc to obtain a reference for the ac:
    a. Note DC DMM indication (approximately 2V).
    b. Repeat step 3 for a -2A dc output. Again note DC DMM indication.
    c. Calculate the average of the values noted in steps a and b.
    d. Adjust the UUT output for a DC DMM reading the same as calculated in step c. This is the average of the positive and negative currents, with respect to the 792A.
    e. Press STORE, OFFSET on the DC DMM. The DC DMM display should now indicate zero.

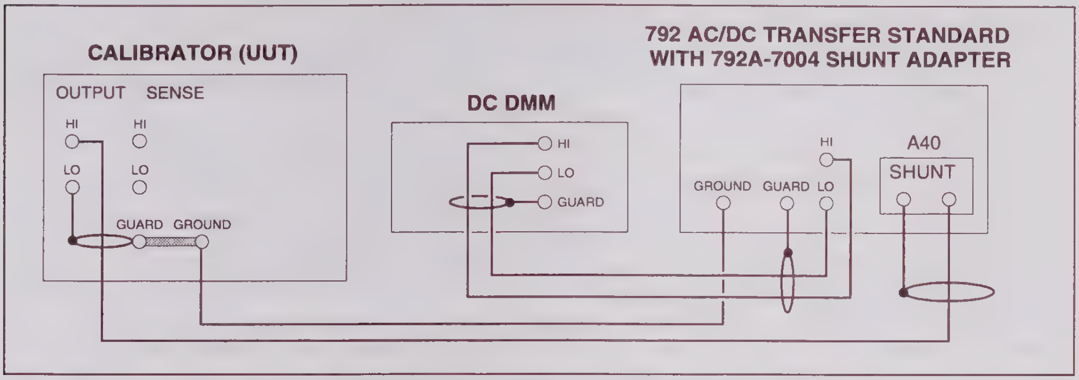


Figure 3-16. Alternating Current Test Setup, 22 mA to 10A (792A)

6. Set the Calibrator to 2A at 40 Hz OPERATE.
7. Adjust the Calibrator output adjustment knob until the DC DMM reads zero. Enter the Calibrator error indication in the test record.
8. Algebraically add the Calibrator error display reading to the A40 Shunt ac to dc difference, record the result on the test record Table 3-35 (5720A) or Table 3-36 (5700A), and verify that the results is within the test limits for the Calibrator.
9. Set the Calibrator to 2A dc. Verify the DC DMM indication returns to that noted in step 5a. If necessary, repeat steps 3 through 9 until the required result is obtained.
10. Change the Calibrator frequency to 1 kHz, 5 kHz, and 10 kHz. At each frequency, edit the Calibrator for a null on the transfer standard null meter. Enter and verify the results as done in steps 7 and 8.
11. Repeat steps 3 through 10 at currents of 200 mA and 20 mA using the appropriate A40 current shunt at the frequencies shown on the test record (Table 3-35 or 3-36).
12. For units with a 5725A Amplifier attached, repeat steps 3 through 10 at 11A using the 10A current shunt at the frequencies listed on the test record.

AC Current Test, 2 mA and 200 μA Ranges (5790A) 3-28.

The equipment required for the alternating current accuracy verification test for the 2 mA and 200 μA ranges is listed in Table 3-13. Use Table 3-37 (5720A) or 3-38 (5700A0 for the test record.

Table 3-13. Equipment Required for Alternating Current Accuracy Test for the 2 mA and 200 μA Ranges

Equipment	Model or Description
AC Measurement Standard	Fluke 5790A
Metal Film Resistor	200Ω, 1/8w, ±1%, T9 (P/N 309724) mounted on a dual banana plug.
Metal Film Resistor	2 kΩ, 1/8w, ±1%, T9 (PN 335422) mounted on a dual banana plug
Cable	Pomona 1368-A-18. Double banana to single banana plugs.

1. Connect the equipment as shown in Figure 3-17.

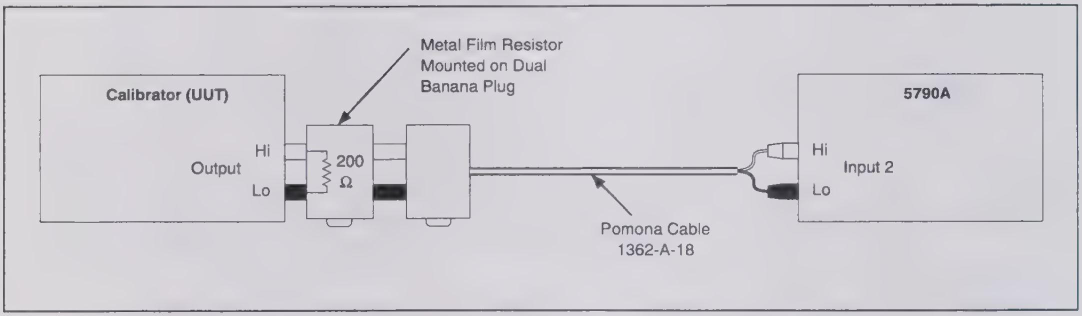


Figure 3-17. Alternating Current Test Setup 2 mA and 200 μA

Note

An explanation of the rationale for using metal film resistors to measure ac current follows this procedure.

2. Set the Calibrator for precisely +2 mA dc using the correction from previously recorded data, i.e. set the Calibrator error display to the value recorded for +2 mA dc (Table 3-10 or 3-11).
3. When the 5790A settles on a reading, push the SET REF soft key on the 5790A.
4. Set the Calibrator for precisely -2 mA dc output using the correction from previously recorded data, i.e., set the Calibrator error display to the value recorded for -2 mA dc, in Table 3-13.
5. Press the AVG REF soft key on the 5790A after the 5790A reading settles.
6. Set the Calibrator to 2 mA at 10 Hz and OPERATE.
7. Record the error displayed on the 5790A in Table 3-37 or 3-38, and verify results are within spec.
8. Return to the error corrected +2 mA DC output that was set in step 2. Verify that the 5790A display returns to a zero reading ±10PPM. If necessary, repeat steps 2 through 6 until the required results are obtained.

9. Change the Calibrator frequency to 20 Hz, 40 Hz, 1 kHz, 5 kHz and 10 kHz. At each frequency record the error display on the 5790A in Table 3-37 or 3-38. Verify that the results are within limits shown.
10. Repeat steps 2 through 9, but replace the 200Ω metal film resistor with the 2 kΩ resistor, and use 200 µA instead of 2 mA.

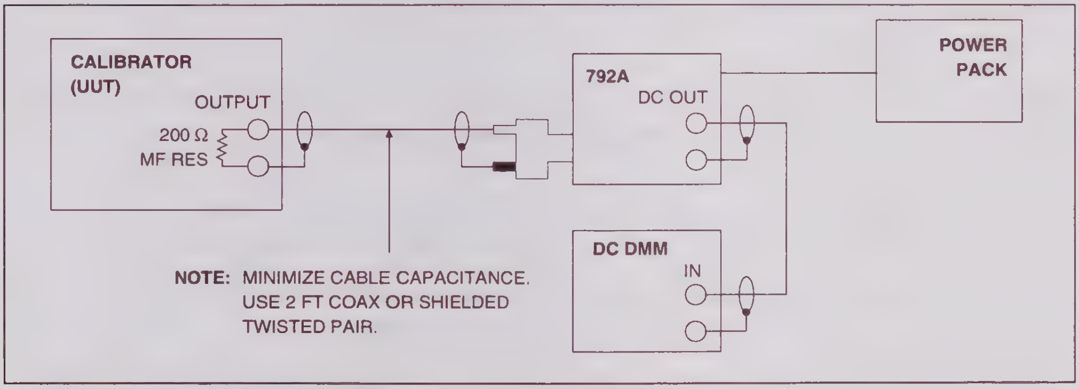
AC Current Test, 2 mA and 200 µA Ranges (792A) 3-29.

If you have a Fluke 792A AC/DC Transfer Standard available, proceed as follows to test the accuracy of the 2 mA ac and 200 µA ac ranges. (If neither a 792A is not available, use the alternate procedure following Optional Test at the end of this chapter.) Use Table 3-39 (5720A) or 3-40 (5700A) for a test record.

1. Connect the equipment as shown in Figure 3-18. Set the 792A INPUT RANGE knob to 700 mV.

Note

An explanation of the rationale for using metal film resistors to measure ac current follows this procedure.



NOTE: MINIMIZE CABLE CAPACITANCE. USE 2 FT COAX OR SHIELDED TWISTED PAIR.

Figure 3-18. Alternating Current Test Setup, 2 mA and 200 µA

2. Set the Calibrator for precisely 2 mA dc using the correction from previously recorded data, i.e. set the error display to the value recorded for +2 mA dc (Table).
3. Allow 1 minute for the 792A to stabilize, then zero the DMM connected to the 792A using the DMM offset function.
4. Reverse the output polarity of the Calibrator. Adjust for any reversal error using the Calibrator output adjustment knob and storing a new offset for equal offset for positive and negative outputs. For example, if the offset when switching to negative output is +0.00004, store a new offset so that with a positive output, the DMM reads -0.00002 and with a negative input, the DMM reads +0.00002.(If you desire, you can produce the same result using the scaling function of the DMM instead of the Calibrator offset function. Set the Calibrator to standby.)
5. Set the Calibrator for 2 mA ac outputs at 10 Hz, 20 Hz, 40 Hz, 1 kHz, 5 kHz, and 10 kHz. At each frequency, adjust the Calibrator output adjustment knob until the dc DMM connected to the 792A reads a null. Record the error display each time in Table 3-39 or 3-40 and verify that it is within the limits shown.

6. Repeat steps 1 through 5, but replace the 200Ω metal film resistor with a 2 kΩ metal film resistor, and use 200 µA instead of 2 mA.

Rationale for Using Metal-Film Resistors to Measure AC Current 3-30.

To be able to measure alternating current, a system comprised of a suitable ac shunt and ac detector is required. First let us consider the ac shunt. For this example we will use a 2 kΩ metal film resistor. At frequencies up to 10 kHz, the equivalent circuit of the resistor can be illustrated as in Figure 3-19. Values typical for shunt capacitance and series inductance are 2 pF (Cs) and 0.01 µH (Ls). For comparison, wire has approximately 0.02 µH/inch. At 10 kHz, the reactance of Cshunt is 8 MΩ, and the reactance of Lseries is 0.6 mΩ. The formulae to use are:

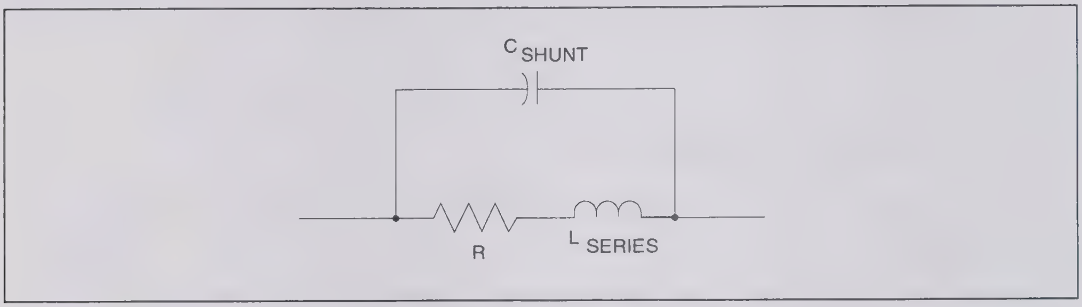


Figure 3-19. Metal Film Resistor Equivalent Circuit

$$(1/Z)^2 = (1/R)^2 + (1/XC)^2 \quad (1)$$

$$(Z)^2 = (R)^2 + (XL)^2 \quad (2)$$

Where R = resistance Xc = Capacitive Reactance
Z = network impedance XL = Inductive Reactance

We can see that these effects can be ignored, because their contribution to errors in the measurement process is less than 1 ppm. That is, the metal film resistor's self reactance is totally dwarfed by the reactance of the measuring circuit, which is overwhelmingly capacitive.

If a detector as shown in Figure 3-20 has an input impedance of 10 MΩ shunted by 123 pF, then the effects of Xc must be accounted for. We can ignore the net resistance change introduced by the 10 MΩ detector resistance.

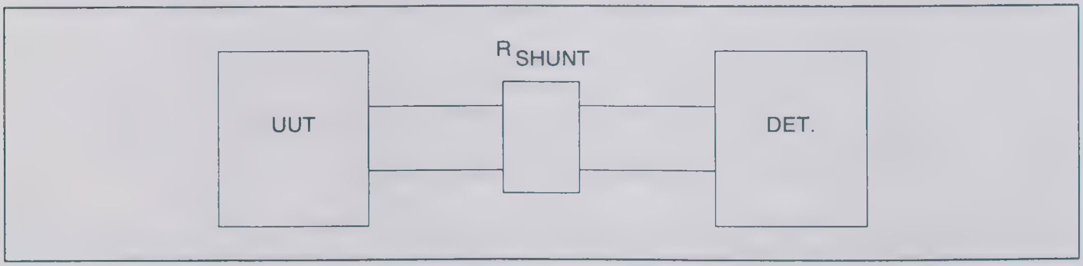


Figure 3-20. Metal Film Resistor in Test Circuit

Note

The input impedance at INPUT 2 of the 5790A on the millivolt ranges is 10 MΩ shunted by 83 pF and the cable used to connect the shunt resistor to the 5790A has 40 pF capacitance, for a total of 123 pF.

The reactance of 123 pF at 10 kHz is 129 kΩ, and using formula (1), in the case where R=2 kΩ, the network impedance Z = 1.999760 kΩ. This produces an error of 120 PPM. The allowable error at 10 kHz is reduced to account for this error.

Note

The input impedance of the 792A millivolt ranges is 30 pF shunted by 10 MΩ. RG/58A coaxial cable has capacitance of about 30 pF/ft.

Using formula (2) we get a result of Xc = 88 kΩ, and a network impedance of Z = 1.9995 kΩ. This produces an error of approximately 250 ppm, or 0.025%. However, if we are making a measurement of 0.21% uncertainty (as in the present case), the ratio of measurement uncertainty is about 10:1 and is not of concern. It is easy to improve measurement uncertainty if desired, though, by measuring the actual input capacitance of the detector and any stray capacitance from input leads, etc. and making corrections. In this discussion, the UUT is assumed to be a high-impedance current source (like the 5700A), which can easily be verified by the manufacturer's specifications, i.e., a specified voltage adder for current outputs above a given burden voltage.

Wideband Frequency Accuracy Test 3-31.

Use Table 3-41 for the test record. Proceed as follows to test the Wideband module frequency accuracy:

1. Connect the Philips PM 6669 to the Calibrator wideband output and measure the output frequency at the frequencies listed in Table 3-41.
2. Verify that the frequency counter indicates frequencies within the 0.01% limits shown.

Wideband AC Voltage Module Output Verification (5790A) 3-32.

The wideband tests are for units with the Option 5700A-03 Wideband AC Module only. The verification test for the wideband module works as follows:

- Accuracy at 1 kHz: Output at 1 kHz is tested by comparing the wideband output at the end of the cable and termination supplied with the instrument to the 5790A at INPUT 2.
- Attenuator flatness: The attenuator flatness is tested using the 5790A wideband input and using reduced spec limits when the TUR (Test Uncertainty Ratio) is less than 4:1.

Table 3-14 lists the equipment required for testing and calibrating the Wideband module.

Table 3-14. Equipment Required for Testing and Calibrating the Wideband Option

Equipment	Model or Description
AC Measurement Standard	Fluke 5790A with Wideband Option -03
Wideband cable	Supplied with 5700A-03
50Ω Termination	Supplied with 5700A-03
Adapter	Pomona 1269 BNC(F) to dual banana plug.
Adapter	Kings KN-99-46 N(F) to BNC(M)

Wideband Output Accuracy at 1 kHz Test (5790A) *3-33.*

This test verifies the Wideband output level at 1 kHz by direct measurement with the 5790A at INPUT 2. Use Table 3-42 for a test record.

Proceed as follows to characterize the rms wideband voltmeter at 1 kHz:

1. Connect the equipment as shown in Figure 3-21.

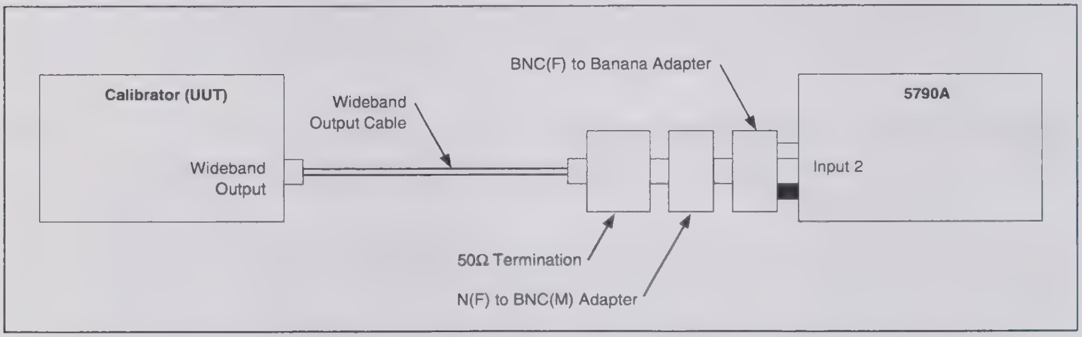


Figure 3-21. Wideband Accuracy at 1 kHz Test Setup

2. Set the Calibrator wideband output to 2.1V at 1 kHz and the 5790A to read INPUT 2.
3. Push the 2.2V RANGE button on the 5790A to lock it on the 2.2V range.
4. On the 5790A push UTIL MENUS button and then MEAS CONTROL soft key. Set the digital filter mode to FAST and the restart to MEDIUM. Push the DONE soft key twice to return to the measurement display.
5. Use the Calibrator output adjustment knob to obtain a reading on the 5790A measurement display of 2.100000 ±20 counts.
6. Read the error on the Calibrator display and record it in Table 3-42 for the 2.1V level for the appropriate verification internal. Verify that it is within spec limits shown.
7. Push the soft key under the RANGE display on the 5790A to return to AUTO RANGE.
8. Proceed to the remaining levels shown in Table 3-42 and repeat steps 5 through 7 with the appropriate output levels set in each step, using the adjustment tolerance in Table 3-15 in step 5.

Table 3-15. Wideband Adjustment Tolerance

5700A/5720A Series II Wideband Output	5790A Adjustment Counts ± ppm
2.10000V	20
1.00000V	10
300.000 mV	3
100.000 mV	10
30.0000 mV	3
10.0000 mV	1
3.00000 mV	1
1000.00 µV	1

Wideband Output Flatness Test (5790A) 3-34.

Use Table 3-43 (5720A) or Table 3-44 (5700A) as a test record. To perform wideband output flatness test, proceed as follows:

1. Connect the equipment as shown in Figure 3-22. Note that the Calibrator wideband cable is connected to the 5790A directly, the termination is not used.

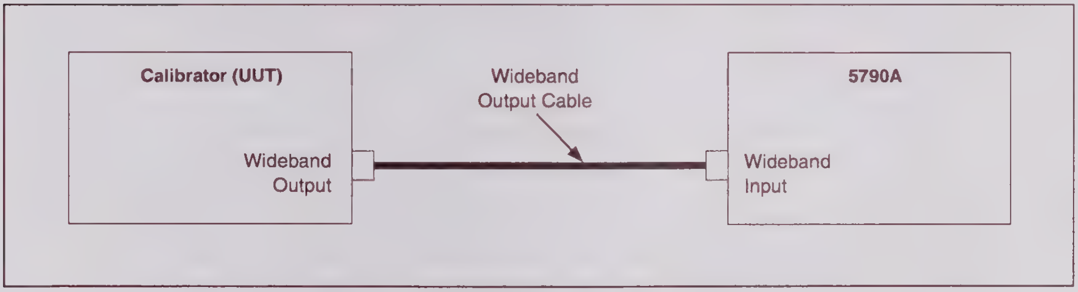


Figure 3-22. Wideband Flatness Test Setup

2. Set the wideband output to 3V at 1 kHz.
3. Push the WBND button on the 5790A, when the reading has settled, push the SET REF soft key.
4. Set the Calibrator to frequencies shown in Table 3-43 for the 3V output and record the errors on the 5790A error display at each frequency in Table 3-43.
5. Verify that the error readings are within spec limits or reduced spec limits shown on the test record. Reduced spec limits are used when the TUR (Test Uncertainty Ratio) is less than 4:1.
6. Repeat steps 4 and 5 for the remaining output levels shown in Table 3-43 using the appropriate voltage in step 4.
7. Record the 1 kHz absolute errors at each output level from Table 3-42 into the appropriate column in Table 3-44. Record the flatness errors from Table 3-43 for each output level and frequency into the appropriate column in Table 3-44. Add the errors and verify that they are within spec for the appropriate time internal.

Wideband Flatness Calibration Procedure (5790A) 3-35.

This procedure is the only part of full verification that stores calibration constants in the Calibrator. This is not a verification test, it is a calibration procedure. Because this part of calibration is recommended to be done only every two years, the same interval as full verification, it is included here and not under Calibration earlier in this chapter and in Chapter 7 of the *5700A/5720A Series II Operator Manual.*

Proceed as follows to perform wideband flatness calibration:

1. Connect the equipment as shown in Figure 3-15 and set the rear panel CALIBRATION switch to the ENABLE position.
2. Push the WBND button on the 5790A.
3. Call up the wideband flatness calibration routine on the Calibrator front panel, by pressing the softkey sequence SETUP MENUS, CAL, CALIBRATION and WIDEBAND FLAT.
4. Enter the present ambient air temperature as prompted and press ENTER.
5. Place the Calibrator in OPERATE. Wideband flatness calibration starts with a 3V output at 1 kHz.
6. Push the SET REF soft key on the 5790A when the 5790A settles to a reading. This is the 3V reference value from which all other frequencies will be compared.
7. Push the ENTER button on the Calibrator, and, the frequency will advance to the next value.
8. Adjust the Calibrator output adjustment knob to bring the 5790A error display to 0 and press ENTER on the Calibrator. Repeat this step for each frequency through 30 MHz.
9. Push the CLEAR REF WBND soft key on the 5790A. The Calibrator wideband output changes to 1V at 1 kHz.
10. Push the SET REF soft key on the 5790A when the 5790A settles to a reading,. This is the 1V reference value from which all other frequencies will be compared.
11. Repeat steps 7 and 8 above for each frequency through 30 MHz.
12. Push the CLEAR REF WBND soft key on the 5790A. The Calibrator Wideband output changes to 300 mV at 1 kHz.
13. Push the SET REF soft key on the 5790A when the 5790A settles to a reading. This is the 300 mV reference value from which all other frequencies will be compared.
14. Repeat steps 7 and 8 above for each frequency through 30 MHz.
15. Push the CLEAR REF WBND soft key on the 5790A. The 5790A wideband output changes to 100 mV at 1 kHz.
16. Push the SET REF soft key on the 5790A when the 5790A settles to a reading. This is the 100 mV reference value from which all other frequencies will be compared.
17. Repeat steps 7 and 8 above for each frequency through 30 MHz. Only the 10 MHz, 20 MHz and 30 MHz points are adjusted.
18. Push the CLEAR REF WBND soft key on the 5790A. The 5790A wideband output changes to 30 mV at 1 kHz.
19. Push the SET REF soft key on the 5790A when the 5790A settles to a reading. This is the 30 mV reference value from which all other frequencies will be compared.
20. Repeat steps 7 and 8 above for each frequency through 30 MHz.

21. Push the CLEAR REF WBND soft key on the 5790A. The 5790A wideband output changes to 10 mV at 1 kHz.
22. Push the SET REF soft key on the 5790A when the 5790A settles to a reading. This is the 10 mV reference value from which all other frequencies will be compared.
23. Repeat steps 7 and 8 above for each frequency through 30 MHz. Only the 10 MHz, 20 MHz and 30 MHz points are adjusted.
24. Make sure the rear panel CALIBRATION switch is in the ENABLE position. Store the cal constants by pushing the STORE VALUES softkey. When the display returns to normal, set the rear panel CALIBRATION switch to NORMAL. The Calibrator wideband flatness calibration is now complete.

Wideband AC Voltage Module Output Verification (792A) 3-36.

The Wideband tests are for units with the Option 5700A-03 Wideband AC Module only. The verification test for the wideband module works as follows:

- Accuracy at 1 kHz: Output at 1 kHz is tested using a characterized rf voltmeter reading the output across a precision dc 50Ω termination.
- Flatness relative to 1 kHz: First the 3V range is tested using the following process:
  1. Characterizing a 50Ω detector using a 3V Thermal Voltage Converter (TVC).
  2. Using the characterized 50Ω detector, read the Calibrator 3V output flatness and record the Calibrator error display to get corrections for the next test. The absolute accuracy at frequencies between 30 Hz and 500 kHz will also be verified by inspection of the data.
- Attenuator Flatness: The attenuator flatness is tested using the following process:
  3. The 3V range corrections are used via Calibrator error display to serve as a reference for characterizing the Attenuator Test Setup at a reduced number of frequencies.
  4. Each attenuator section is tested using a "put and take" method involving removal of 10 dB of external standard attenuation to correspond to each added 10 dB section of the Calibrator.

Table 3-16 lists the equipment required for testing and calibrating the Wideband module.

Table 3-16. Equipment Required for the Wideband Option

Equipment	Model
Wideband RMS Voltmeter	Fluke 8920A
DMM	Fluke 8505A or HP 3458
DMM	Fluke 8840A
3V Thermal Voltage Converter	Fluke A55
20 dB RF Attenuator (Qty. 3)	JFW 50HFI-020N
10 dB RF Attenuator (Qty. 1)	JFW 50HFI-010N
20 dB Amplifier (Qty. 2)	Comlinear CLC100
Ratio Transformer	ESI DT72A
±12V Power Supply	(Any)
0.01 µF Capacitor	(Any)
Wideband Cable	Supplied with Option 5700A-03
50Ω Termination	Supplied with Option 5700A-03

Wideband Output Accuracy at 1 kHz Test (792A) *3-37.*

This test verifies the Wideband output level at 1 kHz by comparing it to the Calibrator main output. This is done by using the Calibrator main output to characterize an rms wideband voltmeter/dc DMM combination. Due to the accuracy specification of the Calibrator Wideband module at 3 mV and 1 mV, it is necessary to ratio down the main output at 3V and 1V to establish a reference at these lower levels. Use Table 3-45 for a test record.

Proceed as follows to characterize the rms wideband voltmeter at 1 kHz:

1. Connect the equipment as shown in Figure 3-13. To eliminate hf noise errors in this measurement, use a common-mode choke and a filter capacitor. The capacitor should be a 0.01 µF. Figure 3-13 shows how to build the common-mode choke.
2. Set the ratio transformer to 0.001.
3. Set the Calibrator main output to 3V and 1V. At each level record the reading of the dc DMM connected to the rms wideband voltmeter in the test record as the 3 mV and 1 mV level.
4. Remove the ratio transformer from the setup and connect the special common mode rejection cable directly to the Calibrator main output terminals.
5. Set the Calibrator main output to the voltage levels from 3V to 10 mV as listed on the test record. At each level record the dc DMM reading on the test record (Table 3-45).
6. Connect the equipment as shown in Figure 3-23.

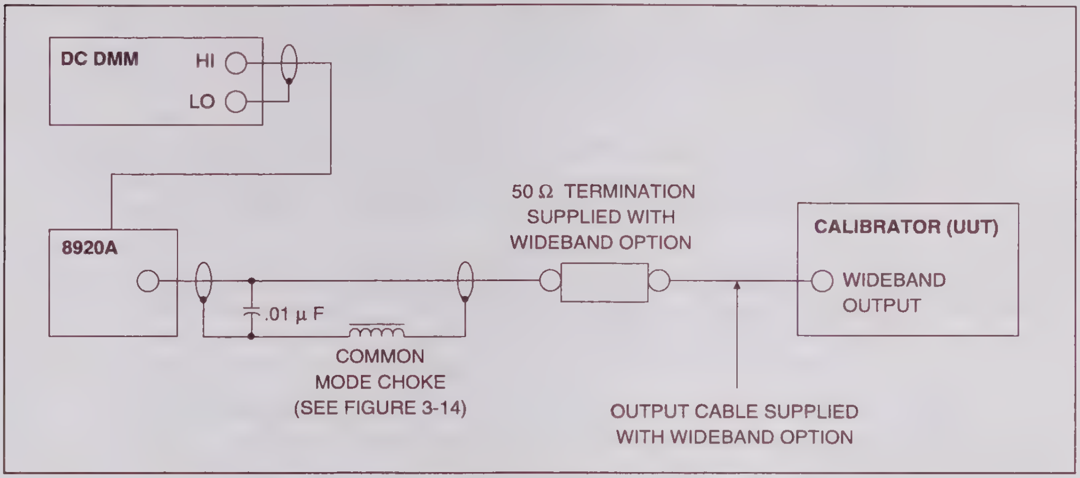


Figure 3-23. Wideband Accuracy at 1 kHz Test Setup

7. Set the Calibrator wideband output for all the levels listed in Table 3-45 and use the output adjustment knob to obtain the dc DMM reading previously recorded. Record the Calibrator error display reading and verify that it is within the limits shown.

Wideband Output Flatness Test (792A) 3-38.

Note

The following test uses a non-50Ω thermal voltage converter (TVC) to characterize a 50Ω system. For Calibrator wideband flatness calibration to be valid, the Calibrator must be connected to a good 50Ω device or system. It is not satisfactory to just parallel the input of the TVC with a good rf 50Ω (especially at frequencies above 10 MHz).However, the TVC will indicate the actual voltage at the center of a Type-874 tee connector in parallel with 50Ω. Therefore, it is valid to calibrate the 50Ω system with the TVC at the other end of a Type-874 tee. **Note that while the TVC is connected, the Calibrator wideband output is functioning only as an uncalibrated voltage source.**

Note

Before beginning this test, obtain a copy of your 3V TVC test report. Any corrections that exceed the following will have to be applied. Note any corrections that exceed these levels for future reference.

- 0.01% to 2 MHz
- 0.02% to 10 MHz
- 0.04% to 20 MHz
- 0.1% to 30 MHz

50Ω System Characterization (792A) 3-39.

First you must perform 50Ω system characterization. To do so, proceed as follows:

1. Connect the equipment as shown in Figure 3-24.
2. Set the Calibrator for a wideband output of 2.7V at 1 kHz.

3. Adjust the Calibrator using the output adjustment knob to obtain a convenient reference reading (such as 0.90000V) on the dc DMM connected to the rms wideband voltmeter analog output. (Note: do not use log output if the meter is so equipped).
4. Allow sufficient time for the TVC to stabilize. Five to ten minutes is sufficient unless the TVC body has not reached ambient temperature before voltage is applied. Zero the 8505A DMM connected to the TVC output using the DMM's offset function.
5. Use the Calibrator output adjustment knob to obtain the 0.90000V reference reading of the rms wideband voltmeter dc DMM. Zero the 8505A DMM connected to the TVC again. Press the Calibrator NEW REF button.

Note

Do not touch the 8505A DMM connected to the 3V TVC output until the text says to do so, unless you begin the test process at 1 kHz again.

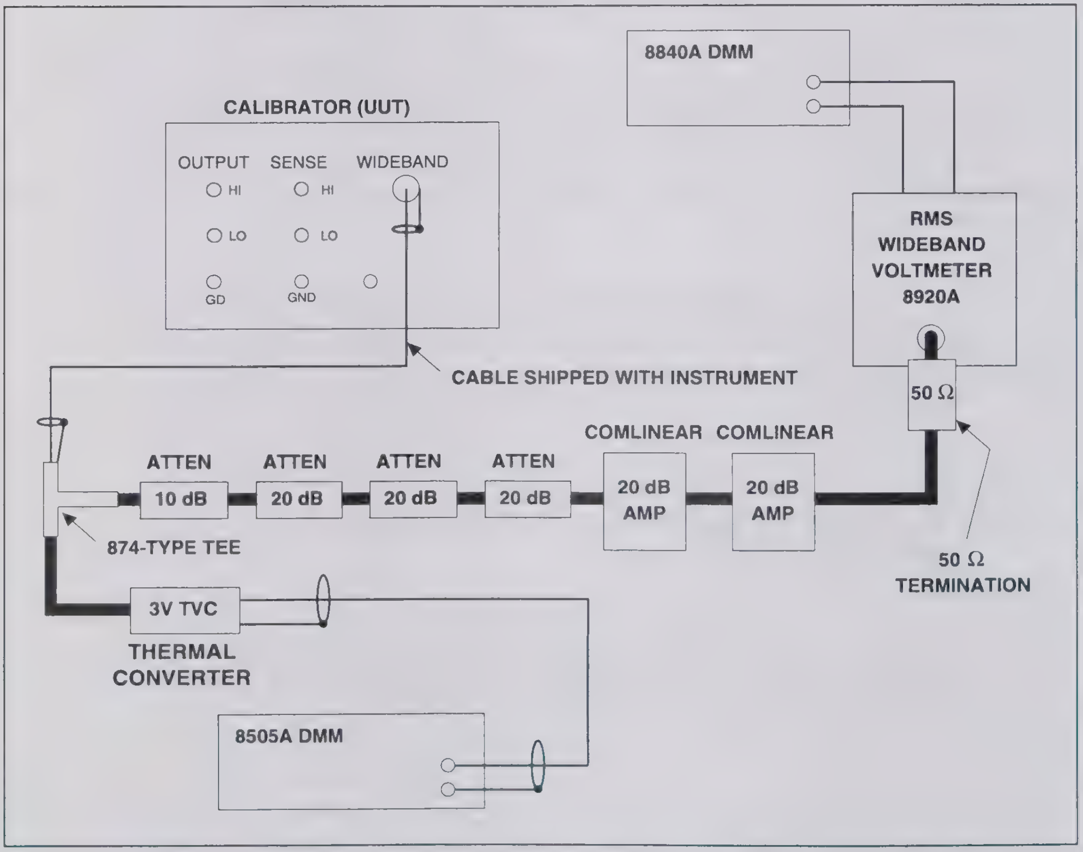


Figure 3-24. Wideband Flatness Calibration Test Setup

6. Program the frequencies shown on the test record (Table 3-46). For each frequency, adjust the Calibrator using the output adjustment knob to obtain a zero on the 8505A DMM that is connected to the TVC output. Then record the rms wideband voltmeter dc DMM reading on the test record (Table 3-46) in the 50Ω DETECTOR CHARACTERIZATION RMS WIDEBAND DC DMM READING column.

Note

If any TVC corrections exceed the criteria stated in the step 1 note, use them by offsetting the 8505A by the opposite sign of the reported value. For example, if the reported rf/dc difference is +0.05%, the UUT output (the one that has been nulled on the 8505A DMM connected to the TVC) must be edited down (the Calibrator output level goes down and the error goes positive) 0.05% before the rms wideband dc DMM reading can be recorded.

7. The last frequency point is to return to 1 kHz. Adjust the Calibrator using the output adjustment knob for a null on the 8505A connected to the TVC and verify that the reading on the rms wideband voltmeter dc DMM is 0.90000V ±0.02%. If it is not, repeat the process beginning at step 2 until this tolerance is met.
8. Set the Calibrator to standby.
9. Remove the 3V TVC, Type-874 tee, and 8505A DMM from the setup. Connect the wideband cable directly to the attenuator string input.

3V Range Wideband Flatness Test (792A) 3-40.

Use Table 3-46 for a test record. Proceed as follows to test the 3V range of the wideband ac module:

1. Leave the test setup connected as described in the last step of the previous procedure.
2. Set the Calibrator for a wideband output of 2.7V at 1 kHz. Adjust the Calibrator using the output adjustment knob until the rms wideband voltmeter dc DMM reads the same reference reading (previous example was 0.90000V) used in the characterization test. Press NEW REF to reference the Calibrator error display to zero.
3. Set the Calibrator to the frequencies listed on the test record. At each frequency, adjust the Calibrator output level using the output adjustment knob to obtain the characterized rms wideband voltmeter dc DMM reading. Record the Calibrator error display for that frequency in the 3V RANGE WIDEBAND FLATNESS TEST ERROR DISPLAY READING column. Verify that the error readings are within the limits shown on the test record. The last frequency is the 1 kHz reference. If the readings do not repeat within 0.02%, do the test process again. Examine the 30 Hz, 120 kHz, and 500 kHz results and verify that when added to the 3V, 1 kHz data from Table 3A-19 that each sum is not larger in magnitude than ±0.22%.
4. Enter the 50Ω system characterization data for the 2 MHz, 10 MHz, 20 MHz, 30 MHz points recorded under the WIDEBAND DC DMM CHAR column DATA of the attenuator flatness test record.

Attenuator Flatness Test (792A) 3-41.

Use Table 3-46 for a test record. Proceed as follows to test the attenuator flatness:

1. With the equipment still connected as in Figure 3-24, remove the 10 dB attenuator and program the Calibrator for a wideband output of 1V, 1 kHz.
2. Use the Calibrator output adjustment knob to obtain the rms wideband voltmeter dc DMM reference level of 0.90000V. Press NEW REF to re-reference the error display to zero.
3. Set the Calibrator to the frequencies listed on the test record. At each frequency, turn the Calibrator output adjustment knob to obtain the rms wideband voltmeter dc DMM characterized data entered on the test record. Record the error display readings

and verify that they are within the limits shown on the test record. Verify that when the 500 kHz error is added to the 1V, 1 kHz data from Table 3-45, the sum is not larger in magnitude than ±0.22%.

4. Repeat the preceding process for the remaining ranges by decreasing the range by 10 dB and the total external attenuation by 10 dB for each range. Note that for the next range (0.3V) you will have to remove a 20 dB section and replace the 10 dB section to achieve a 10 dB shift. The total external attenuation is shown in parentheses near each range value.
5. Set the Calibrator to standby and disconnect the equipment. For each range verify that the 500 kHz results and the 1 kHz results recorded in Table 3-43 total less than the Table 3-43 LIMIT column for that range. This completes wideband verification.

Wideband Flatness Calibration Procedure (792A) 3-42.

This procedure is the only part of full verification that stores calibration constants in the Calibrator. This is not a verification test, it is a calibration procedure. Because this part of calibration is recommended to be done only every two years, the same interval as full verification, it is included here and not under Calibration earlier in this chapter and in Chapter 7 of the *5700A/5720A Series II Operator Manual*.

Note

The following test uses a non-50Ω thermal voltage converter (TVC) to characterize a 50Ω system. For Calibrator wideband flatness calibration to be valid, the Calibrator must be connected to a good 50Ω device or system. It is not satisfactory to just parallel the input of the TVC with a good rf 50Ω (especially at frequencies above 10 MHz).However, the TVC will indicate the actual voltage at the center of a Type-874 tee connector in parallel with 50Ω. Therefore, it is valid to calibrate the 50Ω system with the TVC at the other end of a Type-874 tee. **Note that while the TVC is connected, the Calibrator wideband output is functioning only as an uncalibrated voltage source.**

Note

Before beginning this test, obtain a copy of your 3V TVC test report. Any corrections that exceed the following will have to be applied. Note any corrections that exceed these levels for future reference.

- 0.01% to 2 MHz
- 0.02% to 10 MHz
- 0.04% to 20 MHz
- 0.1% to 30 MHz

Proceed as follows to perform wideband flatness calibration:

1. Connect the equipment as shown in Figure 3-23 and set the rear panel CALIBRATION switch to the ENABLE position.
2. Set the Calibrator for 3V, 1 kHz operate. Select WIDEBAND Type "N" connector output by pressing the WBND key.
3. Adjust the Calibrator output so the DMM connected to the rms wideband voltmeter dc voltage output reads exactly 1V. Press the NEW REF key.
4. Zero the 8505A DMM (using its offset function) that is connected to the 3V TVC output.

5. At each frequency mentioned below, first adjust the Calibrator output until the 8505A DMM connected to the 3V TVC reads 0V, then record the reading of the DMM connected to the rms wideband voltmeter below.

Note

If any TVC corrections exceed the criteria stated in the previous note, use them by offsetting the 8505A DMM by the opposite sign of the reported value. For example, if the reported rf/dc difference is +0.05%, the UUT output(the one that has been nulled on the 8505A DMM connected to the 3V TVC) must be edited down (the Calibrator output level goes down and the error display goes positive)0.05% before the rms wideband dc DMM reading can be recorded.

Frequency 12 kHz, 100 kHz, 500 kHz, 1.1999 MHz, 1.2 MHz

: DMM

Reading:

Frequency 2 MHz, 10 MHz, 20 MHz, 30 MHz, 1 kHz*

: DMM

Reading:

Note

*The rms wideband DMM reading must return to 1V± *0.02% or the test sequence must be repeated.*

6. Remove the 3V TVC, Type-874 tee, and 8505A DMM from the setup. Connect the wideband cable directly to the attenuator string input.
7. Call up the 5700A/5720A Series II Wideband Flatness Calibration routine on the Calibrator front panel by pressing the softkey sequence "Setup Menus", "Cal"," Calibration", "Wideband Flat".
8. Enter the present ambient air temperature as prompted, and press ENTER.
9. Wideband Flatness Calibration starts with a 3V output at 1 kHz. Using the Calibrator output adjustment knob, adjust the output until the DMM connected to the rms wideband voltmeter output reads exactly 1V; then press ENTER.
10. The wideband output frequency changes to 12 kHz. Use the Calibrator output adjustment knob to adjust the output until the DMM reads the voltage that was recorded for 12 kHz in step 5. Press ENTER.

    Repeat this step for each frequency through 30 MHz, adjusting the output each time to match the value recorded in step 5.
11. The Calibrator Wideband output changes to 1V at 1 kHz. Remove the 10 dB attenuator from the test setup, leaving a total attenuation of 60 dB. Use the Calibrator output adjustment knob to adjust the output until the DMM reads the voltage that was recorded for 1 kHz in step 5. Press ENTER.

    Repeat this step for each frequency through 30 MHz, adjusting the output each time to match the value recorded in step 5.
12. The Calibrator Wideband output changes to 300 mV at 1 kHz. Remove a 20 dB attenuator, and replace the 10 dB attenuator on the test setup for a total attenuation of 50 dB. Use the Calibrator output adjustment knob to adjust the output until the DMM reads the voltage that was recorded for 1 kHz in step 5. Press ENTER.

Repeat this step for each frequency through 30 MHz, adjusting the output each time to match the value recorded in step 5.

13. The Calibrator Wideband output changes to 100 mV at 1 kHz. Remove the 10 dB attenuator on the test setup for a total attenuation of 40 dB. Use the Calibrator output adjustment knob to adjust the output until the DMM reads the voltage that was recorded for 1 kHz in step 5. Press ENTER.

    Repeat this step for each frequency, adjusting the output each time to match the value recorded in step 5. This time, only 1 kHz, 10M Hz, 20 MHz, and 30 MHz points are adjusted.

14. The Calibrator Wideband output changes to 30 mV at 1 kHz. Remove another 20 dB attenuator from the test setup for a total attenuation of 30 dB. Use the Calibrator output adjustment knob to adjust the output until the DMM reads the voltage that was recorded for 1 kHz in step 5.

    Repeat this step for each frequency through 30 MHz, adjusting the output each time to match the value recorded in step 5.

15. The Calibrator Wideband output changes to 10 mV at 1 kHz. Remove the 10 dB attenuator from the test setup for a total attenuation of 20 dB. Use the Calibrator output adjustment knob to adjust the output until the DMM reads the voltage that was recorded for 1 kHz in step 5.

    Repeat this step for each frequency, adjusting the output each time to match the value recorded in step 5. This time, only 1 kHz, 10 MHz, 20 MHz, and 30 MHz points are adjusted.

16. Make sure the rear panel CALIBRATION switch is in the ENABLE position, and store the values by pressing a softkey to conclude the Wideband Flatness Calibration procedure. When the display returns to normal, set the rear panel CALIBRATION switch to OFF.

Optional Tests 3-43.

These tests may be used in acceptance testing or following repair likely to affect the characteristics tested here. They are not recommended to be done routinely. If the Calibrator passes Calibration Performance Verification, you do not need to perform these tests; verification either exercises these functions or is subject to their effects. The Optional Tests include such checks as load regulation, noise, and distortion. Equipment required for the optional tests is listed in Table 3-17.

Table 3-17. Equipment Required For DC V Optional Tests

Equipment	Model
DMM	Fluke 8520A
RMS Differential Voltmeter	Fluke 931B
Power Decade Resistor	Clarostat 240C
Differential Amplifier Plug-In	Tektronix 7A22
Oscilloscope Mainframe	Tektronix 7000 Series
DC Voltage Reference Standard	Fluke 732A
Reference Divider	Fluke 752A
Null Detector	Fluke 845A(B or R)
Kelvin-Varley Divider	Fluke 720A

DC Voltage Load Regulation Test *3-44.*

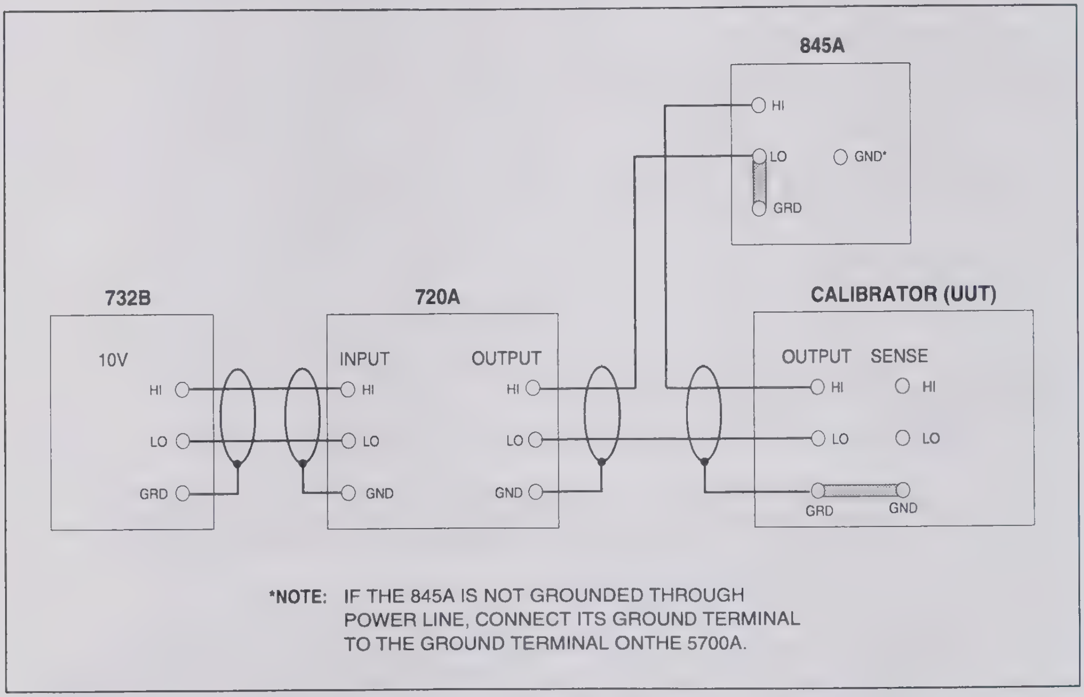
Use Table 3-47 for a test record. Proceed as follows to test the dc voltage load regulation:

1. Ensure the Calibrator is in standby. With the test setup of Figure 3-4, connect the power decade resistor across the Calibrator OUTPUT terminals. Connect two shorting links between the Calibrator SENSE and OUTPUT terminals and select external sense (EX SNS indicator lit).
2. Set the reference divider to 10V. Set the Calibrator output to 10V dc. Set the power decade resistor to 199Ω. Set the Calibrator to operate. Adjust the Calibrator as necessary to obtain a null on the null detector. Rotate the most significant dial on the power decade resistor to 9. Verify that the null detector indication changes less than ±2 μV. Set the Calibrator to standby.
3. Repeat load regulation testing at the remaining Calibrator outputs shown in Table 3-47.
4. Set the Calibrator to standby and disconnect all equipment from the Calibrator.

DC Voltage Linearity Test *3-45.*

Use Table 3-48 for a test record. Proceed as follows to test the dc voltage linearity:

1. Self calibrate the Kelvin-Varley (KV) divider as called for in its service manual.
2. Connect the equipment as shown in Figure 3-25.



*NOTE: IF THE 845A IS NOT GROUNDED THROUGH POWER LINE, CONNECT ITS GROUND TERMINAL TO THE GROUND TERMINAL ONTHE 5700A.

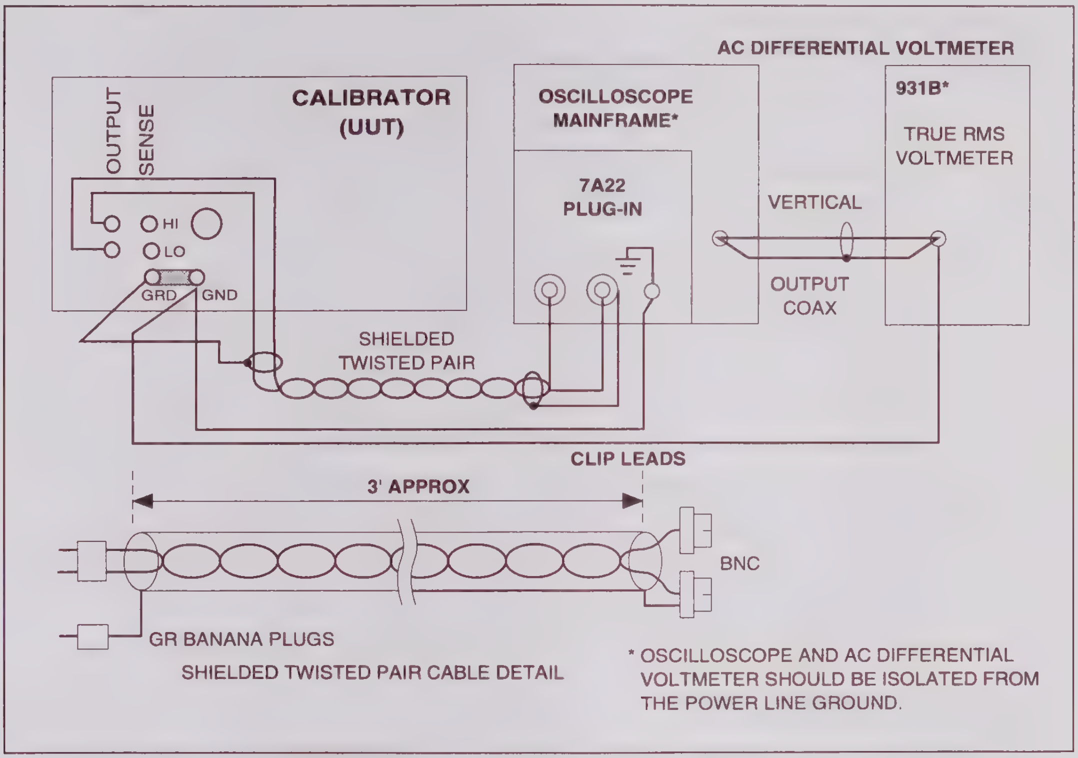
Figure 3-25. DC Voltage Linearity Test

3. Set the KV dials to zero by using the RANGE LOCK. Set the Calibrator to 0V on the 11V range operate. Note the null detector reading. Press OFFSET on the Calibrator.
4. Set KV dials to 0.999999X and Calibrator for a 10V output.
5. Use the Calibrator output adjustment to obtain a null detector reading equal to the reading noted in step 3. Press SCALE on the Calibrator.
6. For each of the KV settings tabulated in Table 3-49, make the required Kelvin Varley setting, and verify that the null detector reads within the limits shown.

DC Voltage Output Noise (10 Hz to 10 kHz) Test *3-46.*

Use Table 3-49 for a test record. Proceed as follows to test the dc voltage output noise that falls in the range 10 Hz to 10 kHz:

1. Connect the equipment as shown in Figure 3-26.



* OSCILLOSCOPE AND AC DIFFERENTIAL VOLTMETER SHOULD BE ISOLATED FROM THE POWER LINE GROUND.

Figure 3-26. DC Voltage Output Noise Test Setup

2. Set the Oscilloscope Differential Amplifier controls as shown below.

Low Frequency -3 dB	10 Hz
High Frequency -3 dB	10 kHz
Input Coupling	AC (both inputs)
Volts/Div	50 µV (Var. to Cal.)

3. Set the Oscilloscope Time/Div for 2 ms.
4. Set the rms voltmeter range to 1V.
5. Set the Calibrator to 2.2V dc, operate. Verify that the reading on the rms voltmeter is less than 150 mV.

NOTE

This test assumes that the amplifier plug-in and scope have a gain equal to 0.5V divided by the input/div. setting, which in the above case is $1x10^4$.

6. Repeat the above process for the remaining tabulated settings shown in Table 3-49; verify that the rms meter indicates less than the amount shown for each required output level.
7. Press RESET on the Calibrator and disconnect the test configuration.

DC Voltage Output Noise (0.1 to 10 Hz) Test 3-47.

Proceed as follows to test for dc voltage output noise in the range 0.1 to 10 Hz:

1. Place the 8520A DMM into Math Program 8 with the Display Option Register set to register 8.3 (Standard Deviation Computed Variable)as follows:
   a. Press SHIFT, 8, and PROGRAM SELECTION. Then press SHIFT, 0, ., 1, PROGRAM SELECTION, 8, ., 3, PROGRAM DATA.
   b. Set the DMM to 200 mV DC Range, 20 Samples/Second, and 1000 ms Filter.
   c. Set PROGRAMS IN USE to the ON position.
2. Lock the Calibrator in the 22V range and set it to 100 mV dc. Place the Calibrator in operate.
3. Connect the DMM to the Calibrator OUTPUT binding posts and press the DMM reset button once. Verify that after 10 seconds the DMM reads less than 0.0010E-3.
4. Lock the Calibrator in the 220V range and set it to 100 mV dc. Place the Calibrator in operate.
5. Press the DMM reset button once. Verify that after 10 seconds the DMM reads less than 0.0100E-3.
6. Set the Calibrator to standby.

AC Voltage Distortion Test 3-48.

Equipment required for these tests is listed in Table 3-18. Proceed as follows to test for distortion in the ac voltage function. Use Table 3-50 for test record.

Table 3-18. Equipment Required for Distortion Test

Equipment	Model
DMM	Fluke 8520A
Distortion Analyzer	HP 334A
Spectrum Analyzer (only for 5700A-03)	HP 8590A
Non-wirewound load resistors	Any (see *Table 3-51 for values)

1. Connect the Calibrator output terminals to the distortion analyzer.
2. Measure the Calibrator distortion at the output voltages and frequencies tabulated in Table 3-50. Verify that the distortion measured is within the limits shown.

Wideband Distortion Testing 3-49.

Proceed as follows to test for distortion in the wideband output function (for units with the Option 5700A-03 Wideband AC Module only).

1. Connect the Wideband output terminated in 50Ω to the spectrum analyzer input.

Note

If the spectrum analyzer input impedance is 50Ω, do not use a separate termination.

2. With 0 dBm output programmed from the Calibrator wideband output, select frequencies over the band of 1 MHz to 30 MHz and verify that use the spectrum analyzer to verify that any harmonics are below -40 dBm for fundamentals up to 10 MHz and below -34 dBm for fundamentals of 10 MHz and above.
3. Disconnect the equipment from the Calibrator.

AC Voltage Overshoot Test 3-50.

Proceed as follows to test for ac voltage overshoot:

1. Connect the Calibrator output to a properly compensated 10:1 probe.
2. AC couple the oscilloscope and set the sweeptime to a fairly low sweeptime (approximately 1 sec/div).
3. Set the Calibrator to 7.07V at 1 kHz, and press OPR/STBY.
4. Set the scope vertical sensitivity for 0.05V/div. Offset the trace vertically until you can see the top of the waveform at the approximate center of the display (must be at least 2-3 divisions down from the top of the scope graticule).
5. Set the Calibrator to standby and then back to operate. Verify that any overshoot visible on the oscilloscope display is less than 1.5 divisions (approximately 10% of the peak value).
6. Repeat the test at 100 Hz and 100 kHz. This completes the Optional Tests.

AC 2 mV Range Flatness Test (792A Only) 3-51.

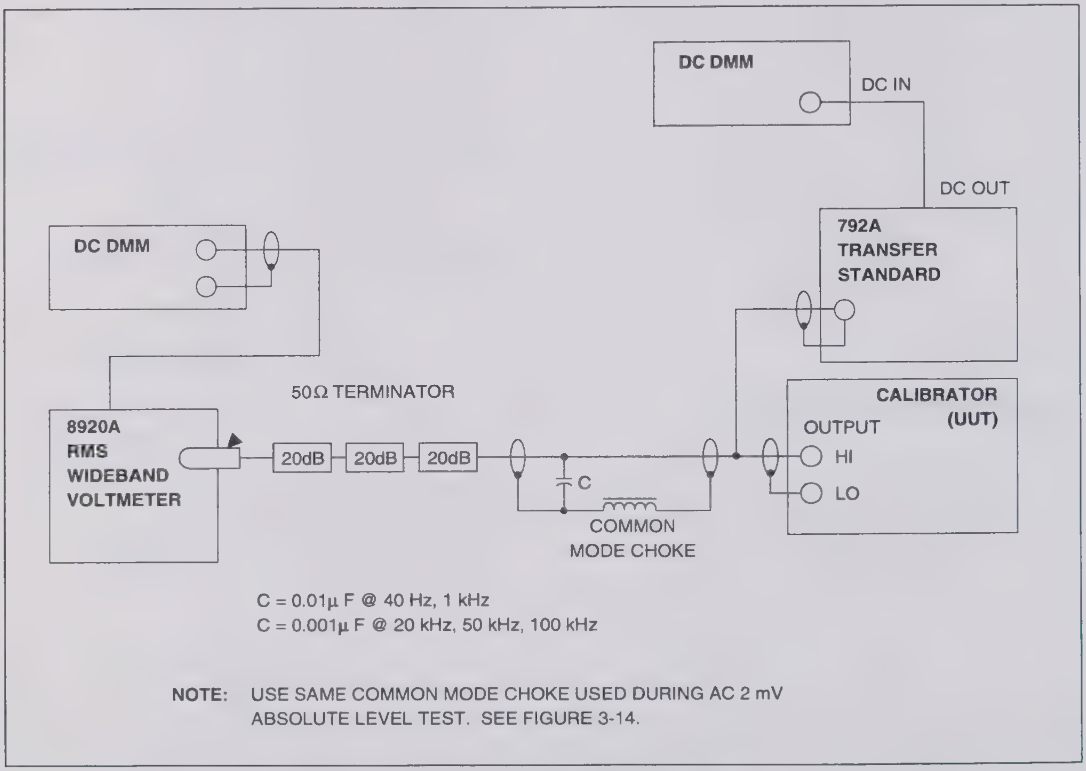
The flatness of the 2 mV range is checked by using the Calibrator 2V range monitored by the 792A transfer standard and 60 dB of attenuation to characterizing a rms wideband voltmeter dc DMM combination. This set up also requires a filter capacitor and a common mode choke. Use Table 3-51 for a test record. Table 3-19 lists equipment required for this test. Proceed as follows:

Table 3-19. Equipment Required for the AC 2 mV Range Flatness Test

Equipment	Model
RMS Wideband Voltmeter	Fluke 8920A
DMM	Fluke 8505A or HP 3458
AC/DC Transfer Standard	Fluke 792A
50Ω Feedthrough Termination	Fluke P/N 853429
20 dB RF Attenuator (Qty. 3)	JFW 50HFI-020N
Common-Mode Choke	(Construction details in Figure 3-14.)

1. Set up the equipment as shown in Figure 3-27. Use three 20 dB attenuators in series and a 0.01 µF capacitor across the input of the rms wideband voltmeter.
2. Set the Calibrator for a 1.9V output at 1 kHz.
3. Allow three minutes for the setup to stabilize and then adjust the Calibrator output using the output adjustment knob until the dc DMM connected to the rms wideband voltmeter reads the same as the "CHARACTERIZED 1.9 MV READING" recorded in Table 3-32. Press the Calibrator NEW REF key to reference the output.
4. Zero the 792A Transfer Standard output dc DMM using the DMM offset function.

5. Set the Calibrator to 40 Hz. Adjust the Calibrator using the output adjustment knob to maintain a null on the 792A output dc DMM. Record the dc DMM reading in Table 3-51.
6. Replace the 0.01 µF capacitor with a 0.001 µF capacitor. Set the Calibrator to 20 kHz, 50 kHz, and 100 kHz, repeating the process of step 5.
7. Remove the 0.001 µF capacitor and set the Calibrator to 300 kHz and 1 MHz, repeating the process of step 5.
8. Reinstall the 0.01 µF capacitor and set the Calibrator to the 1 kHz reference and check for repeatability within ±0.03%.



NOTE: USE SAME COMMON MODE CHOKE USED DURING AC 2 mV ABSOLUTE LEVEL TEST. SEE FIGURE 3-14.

Figure 3-27. AC 2 mV Flatness Test Setup

9. Remove the rf attenuators, 50Ω load, and 792A Transfer Standard from the setup and connect the rms wideband voltmeter dc DMM combination directly to the Calibrator output.
10. Set the Calibrator for 1.9 mV at 40 Hz and 20 kHz. At each frequency adjust the output, using the output adjustment knob, until the dc DMM reading is equal to the previously characterized reading recorded in step 5. Verify that the error display reading is within the limits shown in Table 3-53.
11. Replace the 0.01 µF capacitor with a 0.001 µF capacitor. Repeat the previous step at 50 kHz and 100 kHz. At each frequency edit the output until the dc DMM reads the same as recorded in step 6.
12. Remove the 0.001 µF capacitor. Repeat step 11 at 300 kHz and 1 MHz. At each frequency edit the output until the dc DMM read the same as recorded in step 7.

Alternate Tests (792 Only) 3-52.

The following two test procedures are alternate methods for testing the 20 mV and 200 mV ac voltage ranges and the 2 mA and 200 μA ac current ranges. These tests are for labs without a direct measuring transfer standard for the millivolt and milliamp ranges (such as the Fluke 792A AC/DC Transfer Standard) or the Fluke 5790A AC measurement Standard. Data from the optional AC 2 mV Range Flatness Test is used in this procedure. This test requires that it be performed prior to these alternate tests.

Absolute Level Verification At 1 kHz (200 mV and 20 mV) 3-53.

Use Table 3-52 for a test record. Proceed as follows to do the alternate test for the absolute level of the millivolt ranges at 1 kHz:

1. Connect the equipment as shown in Figure 3-28.
2. Set the Calibrator for a 2V, 1 kHz output and use the output adjustment knob to adjust the error display for the CALCULATED ERROR reading recorded for 2V, 1 kHz in the Output Level Tests for AC Voltage Ranges 20 mV (792A) (Table 3-30 or 3-31).

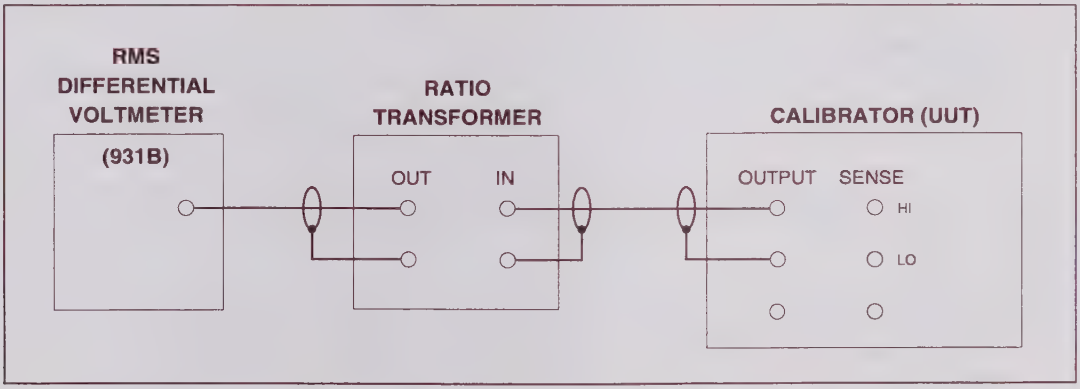


Figure 3-28. Absolute Level Verification at 1 kHz (200 mV and 20 mV)

3. Set the ratio transformer to 0.1, and adjust the rms differential voltmeter dials for a null. Record the dial setting as the 200 mV reading on the test record (Table 3-54).
4. Set the ratio transformer to 0.01 and adjust the rms differential voltmeter dials for a null. Record the dial setting as the 20 mV reading on the test record.
5. Disconnect the ratio transformer from the setup. Use the characterized rms differential voltmeter to measure and record the Calibrator 1 kHz outputs at each characterized 1 kHz voltage level of 20 mV and 200 mV. That is, adjust the Calibrator using the output adjustment knob to obtain the characterized reading on the rms differential voltmeter. Record the Calibrator error display in each case and verify it is within the limits shown.
6. Proceed as follows to test for frequency response. Connect the equipment as shown in Figure 3-28.

Note

The transfer standard used must meet the specification requirements at 2V of item 8 of Table 3-20.

7. Set the Calibrator for a 2V, 1 kHz output. Set the rms differential voltmeter dials to the previously characterized 200 mV, 1 kHz setting. Adjust the Calibrator output using the output adjustment knob for a null on the rms differential voltmeter. Press the NEW REF key on the Calibrator and obtain a reference null on the output of the transfer standard.
8. Set the Calibrator to each of the following frequencies: 10 Hz, 20 Hz, 40 Hz, 20 kHz, 50 kHz, 100 kHz, 300 kHz, 500 kHz, and 1 MHz. At each frequency adjust the Calibrator using the output adjustment knob to maintain a null on the transfer standard. Record the rms differential voltmeter offset in percent up to 100 kHz. At frequencies higher than 100 kHz, set the differential voltmeter dials for a null and record the dial settings in Table 3-52.

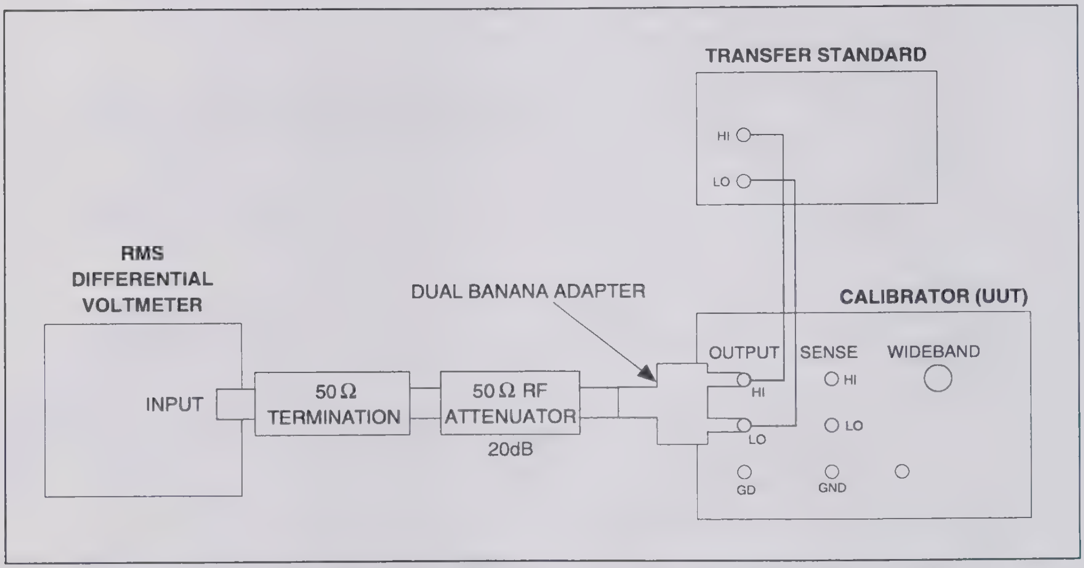


Figure 3-29. 200V and 20 mV Frequency Response Characterization (Alternate test)

9. Return the Calibrator to the 1 kHz reference output and verify that the differential voltmeter and transfer standard come back to the original null within ±0.003% (30 ppm). If not, repeat the process until adequate repeatability is attained.
10. Add a second 20 dB attenuator to the setup of Figure 3-29 and repeat the entire process of steps 7 through 9 to obtain 20 mV rms differential voltmeter corrections. Again, go back to the 1 kHz Level Verification 931 20 mV READING result to obtain the precise rms differential voltmeter reading to use as a reference.
11. Disconnect the transfer standard, attenuators, and termination from the setup and connect the Calibrator output directly to the rms differential voltmeter input.
12. Set the Calibrator for a 200 mV output at all frequencies listed under 200 mV OUTPUT ACCURACY on the test record (Table 3-52). At each frequency, use the Calibrator output adjustment knob to obtain the characterized 200 mV rms differential voltmeter reading. Verify that the Calibrator error display you record is within the limits shown.
13. Repeat step 12 for a Calibrator output of 20 mV.
14. Set the Calibrator to standby and disconnect the rms differential voltmeter.

Alternate 2 mA and 200 μA AC Current Test 3-54.

Use Table 3-53 for a test record. Proceed as follows to do the alternate test for +2 mA and 200 μA ac current ranges:

1. Connect the equipment as shown in Figure 3-30.

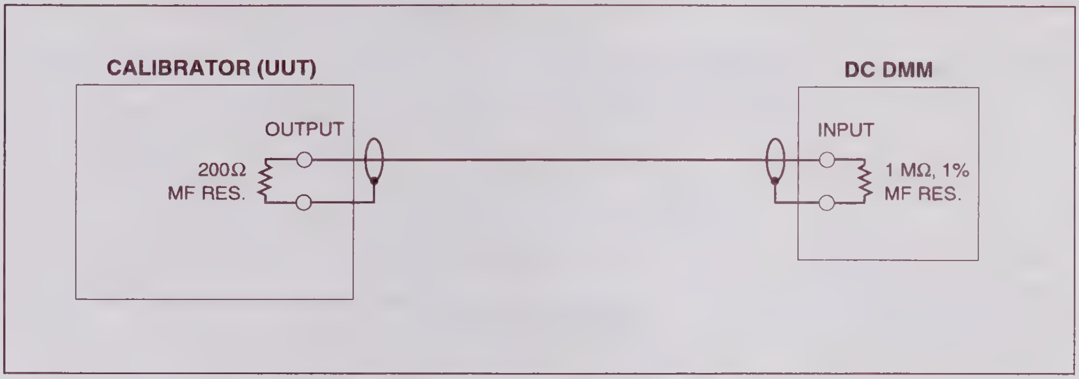


Figure 3-30. 2 mA Reference DC Current Test Setup

2. Set the Calibrator for precisely +2 mA dc using the correction from previous data recorded (i.e. set the error display to the value previously recorded for +2 mA).
3. Record the DMM reading on the line labeled DMM 2 mA DC VOLTAGE READING in the test record (Table 3-55).
4. Remove both resistors from the setup and set the Calibrator dc voltage output to obtain the DMM reading recorded in step 3. Record the Calibrator dc voltage output setting as the CORRECTED 2 mA DC VOLTAGE.
5. Connect the rms differential voltmeter in place of the dc DMM. Set the rms differential voltmeter dials to indicate the voltage just recorded as the CORRECTED 2 mA DC VOLTAGE.

6. Set the Calibrator ac voltage output level to the voltage reading set on the rms differential voltmeter dials. Set the Calibrator frequency to each of 10 Hz, 20 Hz, 40 Hz, 1 kHz, 5 kHz, and 10 kHz. At each frequency, without touching the rms differential voltmeter dials, record the rms differential voltmeter null meter offset in percent in the EXPECTED 2 mA AC READING column.
7. Connect the equipment as shown in Figure 3-31. Using the same 200Ω resistor used in step 1.

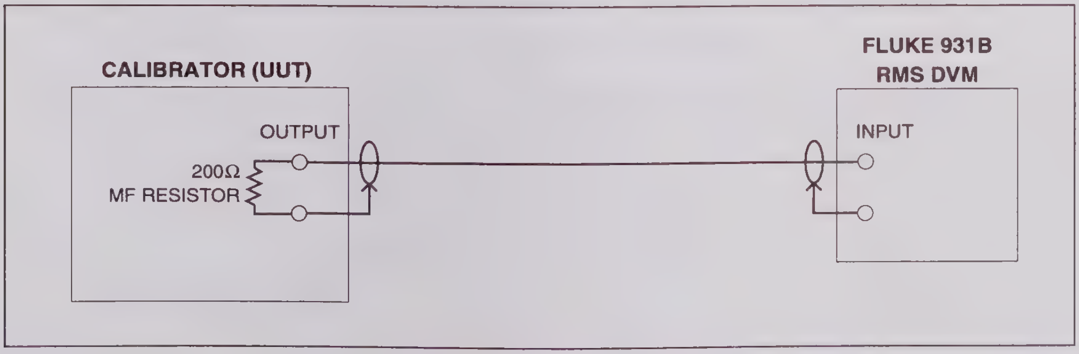


Figure 3-31. 2 mA AC Current Setup

8. Set the Calibrator for 2 mA ac at frequencies used in step 6. At each point, adjust the Calibrator output adjustment knob to obtain the EXPECTED 2 mA AC READING. Record the Calibrator error display indication for each point. Verify that each is within the limits shown.

Repeat steps 1 through 8 to test the 200 µA ac current range using the 2 kΩ metal film resistor in place of the 200Ω metal film resistor.

Minimum Use Requirements *3-55.*

Table 3-20 defines specifications for test equipment needed for tests in this section of the manual. If the specific test equipment called for in these tests is not available, you can substitute equipment that meets these specifications.

Table 3-20. Minimum Use Requirements

Item No.	Description	Minimum Use Specifications	Recommended Equipment
		Calibration Equipment	
1.	Voltage Reference	10V nominal, true value certified to within ±1.5 ppm	Fluke 732A or 732B
2.	Resistance Standards	1Ω nominal, true value certified to within 10 ppm, 10 kΩ nominal, true value certified to within 4 ppm	Fluke 742A Series, 1Ω and 10 kΩ
		Calibration Verification Equipment	
3.	Reference Voltage Divider	Range uncertainty 100:1, 1 kV input, ±0.5 ppm 10:1 100V input ±0.2 ppm	Fluke 752A
4.	Null Detector	Leakage resistance to case: $10^{12}\Omega$ min. Resolution: 3 µV full scale	Fluke 845A
5.	Low Thermal EMF Cables	Plug-in. Copper or gold-flashed copper (two cables per set, two sets required).	Fluke 5440A-7002
		Spade lug. Copper or gold-flashed copper (two cables per set, two sets required).	Fluke 5440A-7003
6.	Digital Multimeter	DC Voltage Range: 0.1 to 10V Resolution and short-term stability: ±2 ppm Resistance range: 1Ω to 10 MΩ Resolution and short-term stability :±20 uΩ at 1Ω, 1.9Ω ±5 ppm at 10Ω, 19Ω ±2 ppm at 100Ω to 1.9 MΩ ±4 ppm at 10 MΩ, 19 MΩ	Fluke 8505A or HP 3458
		Burst memory and math capabilities	Fluke 8520A
7.	Current Source	Range: 10 mA and 100 mA Typical short-term stability ±15 ppm for 5 minutes	Fluke 5100B, 5700A/5720A Series II, or EDC CR103/J
8.	AC Measurement Standard	Ranges: 2.2 mV through 1000V AC Frequency: 10 Hz to 1 MHz 24 to 7500ppm, depending on amplitude and frequency (see Table 3-10.) Wideband Ranges: 2.2 mV through 7V Frequency: 10 Hz to 30 MHz Uncertainty: 0.03% to 0.9%, depending on amplitude and frequency (see Table 3-23.)	Fluke 5790A (Option -03 required for Wideband Flatness Verification)

Table 3-20. Minimum Use Requirements (cont)

Item No.	Description	Minimum Use Specifications	Recommended Equipment
9.	Current Shunt Adapter	Used in conjunction with 5790A and A40-series shunts to facilitate AC Current measurements	Fluke 792A-7004 or Fluke 5790A-7001
10.	AC/DC Transfer Standard	Ranges: 22 mV through 1000V AC Frequency: 10 Hz to 1 MHz Uncertainty: 10 to 1000 ppm, depending on amplitude and frequency (see Table 3A-10)	Fluke 792A
11.	RMS Wideband Voltmeter	Range: 2 mV, analog dc output	Fluke 8920A
12.	Ratio Transformer	Range: 2V input at 1 kHz uncertainty at ratio settings: 0.001 ±250 ppm	ESI DT72A
13.	RF Attenuators	Impedance: 50Ω ±1% at DC Attenuation: 10 dB (1ea.), 20 dB (3 ea.) Temp. Coefficient: 0.0001 dB/dB/°C Frequency Response: 1 GHz, minimum, negligible flatness error to 30 MHz.	JFW 50HFI-010N (1 ea. 10 dB) JFW 50HFI-020N (3 ea. 20 dB)
14.	Frequency Counter	10 Hz to 30 MHz ±0.002%	Philips PM 6669
15.	Standard Resistors	0.1Ω nominal, true value certified to within 20 ppm, rated for 2A DC; 1Ω nominal, true value certified to within 6 ppm; 1.9Ω nominal, true value certified to within 6 ppm; 10Ω nominal, true value certified to within 6 ppm; 1 kΩ nominal, true value certified to within 5.5 ppm; 10 kΩ nominal, true value certified to within 3.5 ppm; 19 kΩ nominal, true value certified to within 4 ppm; 10 MΩ nominal, true value certified to within 15 ppm; 19 MΩ nominal, true value certified to within 28 ppm	Fluke 742A-1 Fluke 742A-1.9 Fluke 742A-10 Fluke 742A-1k Fluke 742A-10k Fluke 742A-19k Fluke 742A-10M Fluke 742A-19M L&N 4221B (0.1Ω)
16.	DC Current Shunt (3)	Range: 10A Uncertainty: ±0.008%	Fluke Y5020
17	AC/DC Current Shunt	Ranges: 20 mA, 200 mA, 2A and 10A Frequency: 10 Hz to 10 kHz Uncertainty: ±310 ppm at 10 Hz; ±100 ppm at 20 Hz; ±50 ppm at 40 Hz, 1 kHz; ±100 ppm at 5 kHz, 10 kHz	Fluke A40-20 mA Fluke A40-200 mA Fluke A40-2A Fluke A40A-10A (3)
18.	Metal Film Resistors	Values: 200Ω, 2 kΩ, and 1 MΩ Temperature C°: T9 or better Power Rating: 1/4 Watt Tolerance: ±1%	Stock Items
19.	Differential Amplifier	Sensitivity: 5 µV rms Bandwidth selectable to 10 kHz	Tektronix 7A22 w/7000-Series Mainframe
20.	Distortion Analyzer	Range: 2V to 300V Frequency: 10 Hz to 600 kHz	HP 334A

Table 3-20. Minimum Use Requirements (cont)

Item No.	Description	Minimum Use Specifications	Recommended Equipment
21.	Thermal Voltage Converter(TVC)	Range: 3V, 10 Hz to 30 MHz AC/DC difference: to 1 MHz: ±0.05% to 10 MHz: ±0.1%, to 20 MHz: ±0.15% to 30 MHz: ±0.25%	Fluke A55
22.	Kelvin-Varley Voltage Divider	Ratio uncertainty: ±0.1 ppm of input	Fluke 720A
23.	HF Spectrum Analyzer (used in optional test for wideband distortion)	Freq. Range: 2 MHz to 120 MHz Input Level: 3V (+20 dBm to -60 dBm)	HP 8590A
24.	RMS Differential Voltmeter (in optional test for wideband distortion) (Note 4)	Input Resistance: 1 MΩ ±1%, shunted by less than 8 pF. Input level: 0 to 1V ac to 10 kHz Stability: ±10 ppm short term at 400 mV input level	Fluke 931B (Fluke 8506A may be used)

1: A Fluke 8505A DMM may be used for all but the 1Ω and 1.9Ω values. For those values using the 8505A, a test method using an external current source is used for low-value resistance.

2: The attenuators are needed only for testing the Wideband AC Voltage Module (Option 5700A-03).

3: Needed only for 5725A Amplifier testing.

Determining Test Limits for Other Calibration Intervals *3-56.*

The verification procedures in this chapter test to the 90 day 99% confidence specification limits. For other calibration intervals it is necessary to calculate new specification limits and, if necessary, new test limits.

The following examples show how the 90 day limits were calculated. These examples illustrate how you can calculate the specifications and test limits, if necessary, for other calibration intervals.

Example 1 shows you how to calculate a specification limit for a specific test level from a specification listed as a percentage (or parts per million) of reading plus a floor error in microvolts, millivolts, miroamps, or nanoamps.

The 99% confidence specification for a 5720A at 2 mA, 1 kHz is 130 ppm + 40 nA. We can convert the floor uncertainty of 40 nA to ppm of output by dividing 40 nA by 2 mA and multiplying by a million:

$$(130 + 1000000*0.000000040/0.002)=130 \text{ ppm} + 20 \text{ ppm} = 150 \text{ ppm}$$

This test limit is shown in Table 3-37.

If we wanted to test to the 1 year specification of 140 ppm + 40 nA, the test limit would be the specification of 140 ppm + 40 nA = 140 ppm + 40 ppm = 180 ppm.

Example 2 shows you how to calculate a specification limit and a tighter test limit. For instrumentation that have the precision of the 5720A/5700A Series II calibrators, it is difficult obtain standards which are many times more accurate than the calibrator specifications. Therefore, for cases when the test uncertainty ratio (TUR) of the standards is less than 4:1, guardbanding is used to set test limits which are tighter than the specification limits. These limits provide the same risk of accepting out of tolerance instruments as a TUR of 4:1. The statistical analysis of the guardbanding techniques used are described in a series of technical papers referenced at the end of this chapter.

Guardbanding is used to set the test limits different than the specification limits for a 5720A at 2V, 1 kHz. The 90 day specification is 47 ppm + 10 uV. When you calculate the specification in ppm at the 2V level in the same way as in Example 1, the specification limit is:

(47 + 1000000*0.000010/2)=47 ppm + 5 ppm = 52 ppm.

If we are testing with a 792A, we see from Test Record Table 3-30 the 792 uncertainty is 10 ppm which results in a TUR of 52/10 = 5.2. Since this is greater than 4, the test limit is the same as the specification limit, 52 ppm.

However, if we choose to verify the same point with a 5790A which has an uncertainty of 24 ppm from the test record in Table 3-28, the resulting TUR is 52/24 = 2.17. Figure 3-32 is used to determine the guardband factor K which is multiplied by the specification limit to determine the test limit. This curve is for 99% confidence level specifications. From Figure 32, we obtain a guardband factor of 0.943 for a TUR of 2.17. The resulting test limit is 52*0.943 = 49 ppm which is the test limit shown for 2V, 1 kHz in the test record.

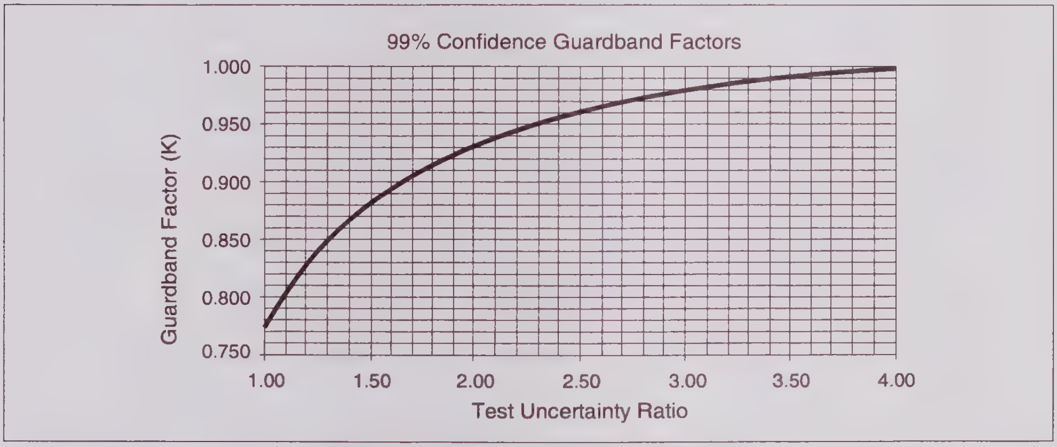


Figure 3-32. Determining Other Test Limits

Table 3-21. 5720A Resistance Test Record

1Ω Std Res Value	1Ω Std Voltage	Measured 1Ω Std Voltage	Cal Current	UUT 1Ω Displayed Value	UUT 1Ω Voltage	UUT True Res	UUT Dev.	Uncert Std	Spec (±ppm)	TUR	GB Factor	Test Limit (±ppm)	Max Difference of Charactized to Nominal Value
								5.9	95	16.06	1.000	95	0.9995 to 1.0005
1.9Ω Std Res Value	1.9Ω Std Voltage	Measured 1.9Ω Std Voltage	Cal Current	UUT 1.9Ω Displayed Value	UUT 1.9Ω Voltage	UUT True Res	UUT Dev.		Spec (±ppm)				Max Difference of Characterized to Nominal Value
								5.9	95	16.06	1.000	95	1.89905 to 1.90095
10Ω Std Res Value	10Ω Std Voltage	Measured 10Ω Std Voltage	Cal Current	UUT 10Ω Displayed Value	UUT 10Ω Voltage	UUT True Res	UUT Dev.		Spec (±ppm)				Max Difference of Characterized to Nominal Value
								5.9	25	4.23	1.000	25	9.997 to 10.004

Resistance Accuracy Verification (19Ω And Above)

	Std Res Value	DMM Std Res Rdg	DMM Error	DMM UUT Res Value	UUT True Res Value	UUT Dev.	Uncert Std	Spec (±ppm)	TUR	GB Factor	Test Limit (±ppm)	Max Difference of Characterized to Nominal Value
19Ω (1)								25				18.9943 to 19.0057
100Ω (1)							5.1	11	2.16	0.970	10.7	99.985 to 100.015
190Ω (1)								11				189.9715 to 190.0285
1 kΩ (1)							4.7	9	1.91	0.926	8.3	999.85 to 1000.15
1.9 kΩ (1)								9				1.899715k to 1.900285k
10 kΩ							3.1	9	2.92	0.978	8.8	9.9985k to 10.0015k
19 kΩ							3.5	9	2.55	0.963	8.7	18.99715k to 19.00285k
100 kΩ(1)							5.1	11	2.15	0.942	10.4	99.985k to 100.015k
190 kΩ (1)								11				189.9715k to 190.0285k
1 MΩ (1)							8.1	18	2.23	0.948	17.1	0.9998M to 1.0002M

Table 3-21. 5720A Resistance Test Record (cont)

	Std Res Value	DMM Std Res Rdg	DMM Error	DMM UUT Res Value	UUT True Res Value	UUT Dev.	Uncert Std	Spec (ppm)	TUR	GB Factor	Test Limit (±ppm)	Max Difference of Characterized to Nominal Value
1.9 MΩ (1)								19				1.89962M to 1.90038M
10 MΩ)							12.0	37	3.07	0.982	36.3	9.997M to 10.003M
19 MΩ							21.9	47	2.15	0.942	44.3	18.9943M to 19.0057M
100 MΩ (2)								110				99.95M to 100.05M

1: Not necessary to test due to 5720A Series II internal calibration process. Uncertainties and test limits are shown for other available 742A Standard Resistors.

2: Due to extremely slow settling time (approximately 5 minutes to 0.005% and sensitivity to any nearby movement, use of the DMM to test 100 megohms to the specified 0.01% uncertainty is not practical and therefore is not recommended. For those who wish to test it, a suitable way is to use an ESI SR 1050 10M/step Hamon-type Resistance Transfer Standard and use it in conjunction with an ESI 242-series bridge to effect the measurement to the required uncertainty.

Table 3-22. 5700A Resistance Test Record

1Ω Std Res Value	1Ω Std Voltage	Measured 1Ω Std Voltage	Cal Current	UUT 1Ω Displayed Value	UUT 1Ω Voltage	UUT True Res	UUT Dev.	Uncert Std	Spec (ppm)	TUR	GB Factor	Test Limit (ppm)	Max Difference of Characterized to Nominal Value
								5.9	95	16.06	1.000	95	0.9995 to 1.0005
1.9Ω Std Res Value	**1.9Ω Std Voltage**	**Measured 1.9Ω Std Voltage**	**Cal Current**	**UUT 1.9Ω Displayed Value**	**UUT 1.9Ω Voltage**	**UUT True Res**	**UUT Dev.**		**Spec (ppm)**	**TUR**	**GB Factor**	**Test Limit (ppm)**	**Max Difference of Characterized to Nominal Value**
								5.9	95	16.06	1.000	95	1.89905 to 1.90095
10Ω Std Res Value	**10Ω Std Voltage**	**Measured 10Ω Std Voltage**	**Cal Current**	**UUT 10Ω Displayed Value**	**UUT 10Ω Voltage**	**UUT True Res**	**UUT Dev.**		**Spec (ppm)**	**TUR**	**GB Factor**	**Test Limit (ppm)**	**Max Difference of Characterized to Nominal Value**
								5.9	28	4.73	1.000	28	9.997 to 10.004

Resistance Accuracy Verification (19Ω And Above)

	Std Res Value	DMM Std Res Rdg	DMM Error	DMM UUT Res Value	UUT True Res Value	UUT Dev.	Uncert. std	Spec (±ppm)	TUR	GB Factor	Test Limit (±ppm)	Max Difference of Characterized to Nominal Value
19Ω (1)												18.9943 to 19.0057
100Ω (1)							5.1	17	3.33	0.990	16.8	99.985 to 100.015
190Ω (1)								11				189.9715 to 190.0285
1 kΩ (1)							4.7	12	2.54	0.963	11.6	999.85 to 1000.15
1.9 kΩ (1)								9				1.899715k to 1.900285k
10 kΩ							3.1	11	3.57	0.994	10.9	9.9985k to 10.0015k
19 kΩ							3.5	11	3.11	0.984	10.8	18.99715k to 19.00285k
100 kΩ(1)							5.1	13	2.54	0.963	12.5	99.985k to 100.015k
190 kΩ (1)								11				189.9715k to 190.0285k
1 MΩ (1)							8.1	18	2.23	0.948	17.1	0.9998M to 1.0002M

Table 3-22. 5700A Resistance Test Record (cont)

	Std Res Value	DMM Std Res Rdg	DMM Error	DMM UUT Res Value	UUT True Res Value	UUT Dev.	Uncert. std	Spec (±ppm)	TUR	GB Factor	Test Limit (±ppm)	Max Difference of Characterized to Nominal Value
1.9 MΩ (1)								±19				1.89962M to 1.90038M
10 MΩ							12.0	±37	3.07	0.982	36.3	9.997M to 10.003M
19 MΩ)							21.9	±47	2.15	0.942	44.3	18.9943M to 19.0057M
100 MΩ (2)								±110				99.95M to 100.05M

1: Not necessary to test due to 5720A Series II internal calibration process. Uncertainties and test limits are shown for other available 742A Standard Resistors.

2: Due to extremely slow settling time (approximately 5 minutes to 0.005% and sensitivity to any nearby movement, use of the DMM to test 100 megohms to the specified 0.01% uncertainty is not practical and therefore is not recommended. For those who wish to test it, a suitable way is to use an ESI SR 1050 10M/step Hamon-type Resistance Transfer Standard and use it in conjunction with an ESI 242-series bridge to effect the measurement to the required uncertainty.

Table 3-23. DC Voltage Test Record for 5720A

Divider Setting	5720A Range	5720A Output (1)	Null Detector Reading(µV) (2)	Null Det Limit (µV)	Meter Limit Rattle (µV)
0.1V	0.22V	0.1V		±1.20 (2)	NA
1V	2.2V	1V		±4.8 µV (2)	0.55
1V	11V	1V (3)		±6 (2)	2.2
10V	11V	10V (4)		±33	3.5
10V	22V	10V (3)		±35	5.5
100V	220V	100V		±45	7.5
1000V	1100V	1000V		±65	4.5
0.1V	0.22V	-0.1V		±1.20 (2)	NA
1V	2.2V	-1V		±4.8 (2)	0.55
10V	11V	-10V		±6.0 (2)	2.2

1: Mathematically, the true 5700A/5720A Series II output programmed is the certified value of the reference standard divided by the reference standard nominal value, multiplied by the required 5700A/5720A Series II nominal output. In other words, the 5700A/5720A Series II output is always programmed for the nominal output adjusted up or down by the same percentage as the certified value of the reference standard.

2: On the 752A 0.1 and 1V ranges, the null detector polarity is reversed. A low input (5700A/5720A Series II output) causes a positive null detector reading.

3: Use Range Lock to obtain 1V on 11V and 10V on 22V range. Deactivate Range Lock before setting the next voltage output.

4: Line regulation can be verified at this time by adjusting the autotransformer for a ±10% change in line voltage. The null detector reading must remain constant within ±1 µV.

Table 3-24. DC Voltage Test Record for 5700A

Divider Setting	5700A Range	5700A Output (1)	Null Detector Reading(μV) (2)	Null Det Limit (μV)	Meter Limit Rattle (μV)
0.1V	0.22V	0.1V		±1.45 (2)	NA
1V	2.2V	1V		±7.2 (2)	0.55
1V	11V	1V (3)		±9 (2)	2.2
10V	11V	10V (4)		±54	3.5
10V	22V	10V (3)		±58	5.5
100V	220V	100V		±70	7.5
1000V	1100V	1000V		±86	4.5
0.1V	0.22V	-0.1V		±1.45 (2)	NA
1V	2.2V	-1V		±7.2 (2)	0.55
10V	11V	-10V		±9.0 (2)	2.2

1: Mathematically, the true 5700A/5720A Series II output programmed is the certified value of the reference standard divided by the reference standard nominal value, multiplied by the required 5700A/5720A Series II nominal output. In other words, the 5700A/5720A Series II output is always programmed for the nominal output adjusted up or down by the same percentage as the certified value of the reference standard.

2: On the 752A 0.1 and 1V ranges, the null detector polarity is reversed. A low input (5700A/5720A Series II output) causes a positive null detector reading.

3: Use Range Lock to obtain 1V on 11V and 10V on 22V range. Deactivate Range Lock before setting the next voltage output.

4: Line regulation can be verified at this time by adjusting the autotransformer for a ±10% change in line voltage. The null detector reading must remain constant within ±1 μV.

Table 3-25. Direct Current Accuracy Test Record (5720A)

Characterizing dc DMM @ ±200 mV and ±2.0V							
Output Current	Std Res Value	DC DMM Setting	Rdg.	Column A Std Res Correction (ppm)	Column B UUT Error Reading (ppm)	UUT Actual Error (A+B) (ppm)	Test Limit, 90-day (±ppm)
+2A	0.1Ω	(200 mV)					78
-2A	0.1Ω	(200 mV)					78
+200 mA	1.0Ω	(200 mV)					49
-200 mA	1.0Ω	(200 mV)					49
+20 mA	10Ω	(200 mV)					38
-20 mA	10Ω	(200 mV)					38
+2 mA	1 kΩ	(2V)					39
-2 mA	1 kΩ	(2V)					39
+200 µA	10 kΩ	(2V)					49
-200 µA	10 kΩ	(2V)					49

Table 3-26. Direct Current Accuracy Test Record (5700A)

Characterizing dc DMM @ ±200 mV and ±2.0V

Output Current	Std Res Value	DC DMM Setting	Rdg	Column A Std Res Correction (ppm)	Column B UUT Error Reading (ppm)	UUT Actual Error (A+B) (ppm)	Test Limit, 90-day (ppm)
+2A	0.1Ω	(200 mV)					95
-2A	0.1Ω	(200 mV)					95
+200 mA	1.0Ω	(200 mV)					65
-200 mA	1.0Ω	(200 mV)					65
+20 mA	10Ω	(200 mV)					55
-20 mA	10Ω	(200 mV)					55
+2 mA	1 kΩ	(2V)					55
-2 mA	1 kΩ	(2V)					55
+200 µA	10 kΩ	(2V)					100
-200 µA	10 kΩ	(2V)					100

5725A Amplifier DC Current Test

Output Current	DC DMM Reading	Certified Shunt Value	Cal Actual Current	Test Limits, 90-day (±ppm)
+10A				388 ppm
-10A				388 ppm
+5A				436 ppm
+3A				500 ppm
-3A				500 ppm

Table 3-27. AC Voltage Frequency Accuracy Test Record

Frequency	Tolerance	Actual
10 Hz	99.99 ms - 100.01 ms	
15 Hz	66.673 ms - 66.66 ms	
100 Hz	9.999 ms - 10.001 ms	
200 Hz	199.98 Hz - 200.02 Hz	
500 Hz	499.95 Hz - 500.05 Hz	
1 kHz	999.9 Hz - 1000.1 Hz	
5 kHz	4999.5 Hz - 5000.5 Hz	
10 kHz	9.999 kHz - 10.001 kHz	
140 kHz	139.986 kHz - 140.014 kHz	
200 kHz	199.98 kHz - 200.02 kHz	
500 kHz	499.95 kHz - 500.05 kHz	
1 MHz	0.9999 MHz - 1.0001 MHz	

Table 3-28. 5720A AC Voltage Output Test Record (5790A)

Output Level	Frequency	Error Display Reading	Spec (± ppm)	5790A 1-Year Spec (± ppm)	TUR	GB Factor	Test Limit (4) (± ppm)
90-Day Test Record							
2 mV	1 kHz		2590	1070	2.42	0.958	2480
2 mV	20 kHz		2590	1070	2.42	0958	2480
2 mV	50 kHz		2730	1810	1.51	0.882	2408
2 mV	100 kHz		3540	2450	1.44	0.874	3093
2 mV	300 kHz		7200	4300	1.67	0.903	6498
2 mV	500 kHz		14000	6400	2.19	0.945	13223
2 mV	1 MHz		15600	7500	2.08	0.938	14637
2 mV	40 Hz		2950	1070	2.42	0.958	2480
2 mV	20 Hz		2605	1390	1.87	0.923	2403
2 mV	10 Hz		2770	2350	1.18	0.823	2280
20 mV	1 kHz		340	175	1.94	0.928	316
20 mV	20 kHz		340	175	1.94	0.928	316
20 mV	50 kHz		480	310	1.55	0.887	426
20 mV	100 kHz		840	435	1.93	0.928	779
20 mV	300 kHz		1800	1010	1.78	0.914	1646
20 mV	500 kHz		2750	1290	2.13	0.942	2789
20 mV	1 MHz		4350	2100	2.07	0.938	4079
20 mV	40 Hz		340	175	1.94	0.928	316
20 mV	20 Hz		355	255	1.94	0.866	307
20 mV	10 Hz		520	355	1.46	0.877	456
200 mV	1 kHz		130	45	2.89	0.977	127
200 mV	20 kHz		130	45	2.89	0.977	127
200 mV	50 kHz		270	79	3.42	0.990	267
200 mV	100 kHz		640	172	3.72	0.996	638
200 mV	300 kHz		1025	270	3.80	0.997	1022
200 mV	500 kHz		1650	420	3.93	0.999	1648
200 mV	1 MHz		3200	1040	3.08	0.982	3143
200 mV	40 Hz		130	45	2.89	0.977	127
200 mV	20 Hz		245	92	1.58	0.891	129
200 mV	10 Hz		345	217	1.59	0.892	308
2V	1 kHz		52	24	2.17	0.943	49
2V	20 kHz		52	24	2.17	0.943	49
2V	50 kHz		91	46	1.98	0.931	85
2V	100 kHz		145	71	2.04	0.936	136
2V	300 kHz		470	160	2.94	0.978	460
2V	500 kHz		1225	260	4.70	1.000	—
2V	1 MHz		2100	900	2.23	0.953	2001
2V	40 Hz		52	24	2.17	0.943	49
2V	20 Hz		110	66	1.67	0.901	99
2V	10 Hz		295	200	1.48	0.878	259
2.3V(1)	1 kHz		81	24	3.37	0.989	80
20V	1 kHz		52	27	1.87	0.923	47
20V	20 kHz		52	27	1.87	0.923	47
20V	50 kHz		91	48	1.90	0.924	84
20V	100 kHz		128	81	1.57	0.891	114
20V	300 kHz		350	190	1.84	0.920	322
20V	500 kHz		1225	400	3.06	0.982	1203
20V	1 MHz		1800	1200	1.50	0.881	1585
20V(2)	40 Hz		52	27	1.87	0.923	47
20V	20 Hz		110	67	1.64	0.899	99
20V	10 Hz		295	200	1.48	0.878	259

Table 3-28. 5720A AC Voltage Test Record (5790A) (cont)

Output Level	Frequency	Error Display Reading	Spec (± ppm)	5790A 1-Year Spec (± ppm)	TUR	GB Factor	Test Limit (4) (± ppm)
200V	1 kHz		64	31	2.05	0.936	59
200V	20 kHz		64	31	2.05	0.936	59
200V	50 kHz		101	69	1.46	0.875	88
200V	100 kHz		185	98	1.89	0.923	171
200V(2)	40 Hz		64	31	2.05	0.936	59
200V	20 Hz		110	68	1.62	0.896	99
200V	10 Hz		295	200	1.48	0.878	259
300V(3)	20 kHz		145	41	3.54	.993	144
600V(3)	50 kHz		378	130	2.91	.977	369
600V(3)	100 kHz		1375	500	2.21	.945	1299
1 kV	1 kHz		79	38	2.08	0.938	74
1 kV	50 Hz		79	38	2.08	0.938	74
1 kV	300 Hz		79	38	2.08	0.938	74
1 kV(3)	20 kHz		131	38	3.45	.991	130
1 kV(3)	30 kHz		371	130	2.85	.975	362
1 kV(3)	40 Hz		84	38	2.21	.945	79

1: This is a test of the bottom of the 20V range .
2: Observe the Calibrator output for 10 minutes and verify that it remains stable within ±7.5 ppm.
3: Perform only for units that are used with a 5725A Amplifier.
4: When the TUR (Test Uncertainty Ratio) is less than 4:1, the spec is reduced to give the same Consumer Risk as a 4:1 TUR as described later in this chapter.

Table 3-29. 5700A AC Voltage Output Test Record (5790A)

Output Level	Frequency	Error Display Reading	Spec (± ppm)	5790A 1-Year Spec (± ppm)	TUR	GB Factor	Test Limit (4) (± ppm)
90-Day Test Record							
2 mV	1 kHz		2610	1070	2.44	0.958	2500
2 mV	20 kHz		2610	1070	2.44	0.958	2500
2 mV	50 kHz		2870	1810	1.59	0.892	2561
2 mV	100 kHz		4900	2450	2.00	0.932	4568
2 mV	300 kHz		8700	4300	2.02	0.932	8128
2 mV	500 kHz		16700	6400	2.61	0.966	16132
2 mV	1 MHz		24400	7500	3.25	0.987	24078
2 mV	40 Hz		2610	1070	2.44	0.958	2500
2 mV	20 Hz		2720	1390	1.96	0.928	2524
2 mV	10 Hz		3050	2350	1.30	0.848	2586
20 mV	1 kHz		410	175	2.34	0.953	391
20 mV	20 kHz		410	175	2.34	0.953	391
20 mV	50 kHz		670	310	2.16	0.943	632
20 mV	100 kHz		1300	435	2.99	0.980	1274
20 mV	300 kHz		1950	1010	1.93	0.927	1808
20 mV	500 kHz		3200	1290	2.48	0.960	3072
20 mV	1 MHz		6400	2100	3.05	0.982	6280
20 mV	40 Hz		410	175	2.34	0.950	390
20 mV	20 Hz		520	255	2.04	0.935	486
20 mV	10 Hz		850	355	2.39	0.956	813
200 mV	1 kHz		150	45	3.33	0.988	148
200 mV	20 kHz		150	45	3.33	0.988	148
200 mV	50 kHz		380	79	4.81	1.000	—
200 mV	100 kHz		950	172	5.52	1.000	—
200 mV	300 kHz		1150	270	4.26	1.000	—
200 mV	500 kHz		1900	420	4.52	1.000	—
200 mV	1 MHz		3800	1040	3.65	0.995	3781
200 mV	40 Hz		150	45	3.33	0.988	148
200 mV	20 Hz		270	92	2.93	0.978	264
200 mV	10 Hz		630	217	2.90	0.977	616
2V	1 kHz		78	24	3.25	0.987	77
2V	20 kHz		78	24	3.25	0.987	77
2V	50 kHz		140	46	3.04	0.980	137
2V	100 kHz		290	71	4.08	1.000	—
2V	300 kHz		515	160	3.22	0.986	508
2V	500 kHz		1300	260	5.00	1.000	—
2V	1 MHz		2700	900	3.00	0.980	2646
2V	40 Hz		78	24	3.25	0.987	77
2V	20 Hz		185	66	2.80	0.974	180
2V	10 Hz		600	200	3.00	0.980	588
2.3V(1)	1 kHz		105	24	4.38	1.000	—
20V	1 kHz		78	27	2.89	0.977	77
20V	20 kHz		78	27	2.89	0.977	77
20V	50 kHz		140	48	2.92	0.978	137
20V	100 kHz		270	81	3.33	0.988	267
20V	300 kHz		635	190	3.34	0.988	627
20V	500 kHz		1550	400	3.88	0.998	1547
20V	1 MHz		3250	1200	2.71	0.970	3153
20V(2)	40 Hz		78	27	2.89	0.977	77
20V	20 Hz		185	67	2.76	0.972	180
20V	10 Hz		600	200	3.00	0.980	588

Table 3-29. 5700A AC Voltage Output Test Record (5790A) (cont)

Output Level	Frequency	Error Display Reading	Spec (± ppm)	5790A 1-Year Spec (± ppm)	TUR	GB Factor	Test Limit (4) (± ppm)
200V	1 kHz		85	31	2.74	0.971	83
200V	20 kHz		85	31	2.74	0.971	83
200V	50 kHz		240	69	3.48	0.991	238
200V	100 kHz		600	98	6.12	1.00	—
200V(2)	40 Hz		85	31	2.74	0.972	83
200V	20 Hz		185	68	2.72	0.970	179
200V	10 Hz		600	200	3.00	0.980	588
300V(3)	20 kHz		145	41	3.54	0.993	144
600V(3)	50 kHz		378	130	2.91	0.977	369
600V(3)	100 kHz		1375	500	2.21	0.945	1299
1 kV	1 kHz		84	38	2.21	0.945	79
1 kV	50 Hz		84	38	2.21	0.945	79
1 kV	300 Hz		84	38	2.21	0.945	79
1 kV(3)	20 kHz		131	38	3.45	0.991	130
1 kV(3)	30 kHz		371	130	2.85	0.975	362
1 kV(3)	40 Hz		84	38	2.21	0.945	79

1: This is a test of the bottom of the 20V range .
2: Observe the Calibrator output for 10 minutes and verify that it remains stable within ±7.5 ppm.
3: Perform only for units that are used with a 5725A Amplifier.
4: When the TUR (Test Uncertainty Ratio) is less than 4:1, the spec is reduced to give the same Consumer Risk as a 4:1 TUR as described later in this chapter.

Table 3-30. 5720A AC Voltage Output Test Record (792A)

Output Level	Frequency	Transfer Standard Correction	Error Display Reading	Calculated Error	90-Day Spec. (±ppm)	792A Uncert (±ppm)	TUR	GB Factor	Test Limit (±ppm) (4)
2V	1 kHz				52	10	5.20	1000	52
2V	20 kHz				52	10	5.20	1000	52
2V	50 kHz				91	40	2.28	0.950	86
2V	100 kHz				145	50	2.90	0.977	142
2V	300 kHz				470	115	4.09	1.000	470-
2V	500 kHz				1225	125	9.80	1.000	1225
2V	1 MHz				2100	125	16.8	1.000	2100
2V	40 Hz				52	25	2.08	0.938	49
2V	20 Hz				110	60	1.83	0.919	101
2V	10 Hz				295	190	1.55	0.889	262
2.3V (1)	1 kHz				77	10	7.74	1.000	77
20V	1 kHz				50.5	15	3.37	0.989	50
20V	20 kHz				50.5	15	3.37	0.989	50
20V	50 kHz				91	40	2.28	0.950	86
20V	100 kHz				128	50	2.55	0.964	123
20V	300 kHz				350	120	2.92	0.978	342
20V	500 kHz				1225	125	9.80	1.000	1225
20V	1 MHz				1800	125	14.40	1.000	1800
20V (2)	40 Hz				50.5	25	2.02	0.934	47
20V	20 Hz				110	60	1.83	0.919	101
20V	10 Hz				295	190	1.55	0.889	262
200 mV	1 kHz				130	30	4.33	1.000	130
200 mV	20 kHz				130	30	4.33	1.000	130
200 mV	50 kHz				270	65	4.15	1.000	270
200 mV	100 kHz				640	150	4.27	1.000	640
200 mV	300 kHz				1025	220	4.66	1.000	1025
200 mV	500 kHz				1650	250	6.60	1.000	1650
200 mV	1 MHz				3200	300	10.67	1.000	3200
200 mV	40 Hz				130	40	3.25	0.987	128
200 mV	20 Hz				145	80	1.81	0.917	133
200 mV	10 Hz				345	200	1.73	0.908	313

Table 3-30. 5720A AC Voltage Output Test Record (792A) (cont)

Output Level	Frequency	Transfer Standard Correction	Error Display Reading	Calculated Error	90-Day Spec. (±ppm)	792A Uncert. (±ppm)	TUR	GB Factor	Test Limit (±ppm) (4)
20 mV	1 kHz				340	125	2.27	0.971	330
20 mV	20 kHz				340	125	2.72	0.971	330
20 mV	50 kHz				480	200	2.40	0.957	459
20 mV	100 kHz				840	450	1.87	0.922	774
20 mV	300 kHz				1800	650	2.77	0.973	1751
20 mV	500 kHz				2750	1000	2.75	0.972	2673
20 mV	1 MHz				4350	1000	4.35	1.000	4350
20 mV	40 Hz				340	140	2.43	0.958	326
20 mV	20 Hz				355	180	1.97	0.931	330
20 mV	10 Hz				520	280	1.86	0.921	479
200V	1 kHz				64	18	3.53	0.993	63
200V	20 kHz				110	60	1.83	0.919	101
200V	50 kHz				295	190	1.55	0.889	262
200V	100 kHz				145	70	4.39	1.000	145
200V (2)	40 Hz				64	60	2.35	0.954	61
200V	20 Hz				110	60	1.83	0.919	101
200V	10 Hz				295	190	1.55	0.889	262
300V (3)	20 kHz				145	33	4.39	1.000	145
600V (3)	50 kHz				378	50	7.56	1.000	378
600V (3)	100 kHz				1375	70	15.64	1.000	1375
1000V	1 kHz				79	25	3.16	0.985	78
1000V	50 Hz				79	27	2.92	0.978	77
1000V	300 Hz				79	25	3.16	0.985	78
1000V (3)	20 kHz				131	27	4.85	1.000	131
1000V (3)	30 kHz				371	60	6.18	1.000	371
1000V (3)	40 Hz				84	27	3.11	0.983	83

1: This is a test of the bottom of the 20V range and will require re-referencing at 2.3V dc.

2: Observe the 5720A Series II output for 10 minutes and verify that it remains within ±7.5 ppm. Return to 1 kHz and algebraically subtract from the reading any drift from the 792A.

3: Perform only for units that are used with a 5725A Amplifier.

4: When the TUR (Test Uncertainty Ratio) is less than 4:1, the spec is reduced to give the same Consumer Risk as a 4:1 TUR as described later in this chapter.

Table 3-31.5700A AC Voltage Output Test Record (792A)

Output Level	Frequency	Transfer Standard Correction	Error Display Reading	Calculated Error	90-Day Spec. (±ppm)	792A Uncert. (±ppm)	TUR	GB Factor	Test Limit (±ppm) (4)
2V	1 kHz				78.5	10	7.85	1.000	78.5
2V	20 kHz				78.5	10	7.85	1.000	78.5
2V	50 kHz				140	40	3.50	0.992	139
2V	100 kHz				290	50	5.80	1.000	290
2V	300 kHz				515	115	4.48	1.000	515
2V	500 kHz				1300	125	10.40	1.000	1300
2V	1 MHz				2700	125	21.60	1.000	2700
2V	40 Hz				78.5	25	3.14	0.984	77
2V	20 Hz				185	60	3.08	0.919	182
2V	10 Hz				600	190	3.16	0.985	591
2.3V (1)	1 kHz				105.4	10	10.54	1.000	105.4
20V	1 kHz				78.5	15	5.23	1.000	78.5
20V	20 kHz				78.5	15	5.23	1.000	78.5
20V	50 kHz				140	40	3.50	0.992	139
20V	100 kHz				270	50	5.40	1.000	270
20V	300 kHz				635	120	5.29	1.000	635
20V	500 kHz				1550	125	12.40	1.000	1550
20V	1 MHz				3250	125	26.00	1.000	3250
20V (2)	40 Hz				78.5	25	3.14	0.984	77
20V	20 Hz				185	60	3.08	0.983	182
20V	10 Hz				600	190	3.16	0.985	591
200 mV	1 kHz				150	30	5.00	1.000	150
200 mV	20 kHz				150	30	5.00	1.000	150
200 mV	50 kHz				380	65	5.85	1.000	380
200 mV	100 kHz				950	150	6.33	1.000	950
200 mV	300 kHz				1150	220	5.23	1.000	1150
200 mV	500 kHz				1900	250	7.60	1.000	1900
200 mV	1 MHz				3800	300	12.67	1.000	3800
200 mV	40 Hz				150	40	3.75	0.997	149
200 mV	20 Hz				270	80	3.38	0.990	267
200 mV	10 Hz				630	200	3.15	0.985	620

Table 3-31. 5700A AC Voltage Output Test Record (792A) (cont)

Output Level	Frequency	Transfer Standard Correction	Error Display Reading	Calculated Error	90-Day Spec. (±ppm)	792A Uncert. (±ppm)	TUR	GB Factor	Test Limit (±ppm) (4)
20 mV	1 kHz				410	125	3.28	0.988	405
20 mV	20 kHz				410	125	3.28	0.988	405
20 mV	50 kHz				670	200	3.35	0.989	663
20 mV	100 kHz				1300	450	2.89	0.977	1270
20 mV	300 kHz				1950	650	3.00	0.980	1912
20 mV	500 kHz				3200	1000	3.20	0.986	3154
20 mV	1 MHz				6400	1000	6.40	1.000	6400
20 mV	40 Hz				410	140	2.93	0.978	401
20 mV	20 Hz				520	180	2.89	0.977	508
20 mV	10 Hz				850	280	3.04	0.981	834
200V	1 kHz				85	18	4.72	1.000	85
200V	20 kHz				85	18	4.72	1.000	85
200V	50 kHz				240	60	4.00	1.000	240
200V	100 kHz				600	70	8.57	1.000	600
200V (2)	40 Hz				85	27	3.15	0.984	84
200V	20 Hz				185	60	3.08	0.983	182
200V	10 Hz				600	190	3.16	0.985	591
300V (3)	20 kHz				145	33	4.39	1.000	145
600V (3)	50 kHz				378	50	7.56	1.000	378
600V (3)	100 kHz				1375	70	19.64	1.000	1375
1000V	1 kHz				84	25	3.36	0.989	83
1000V	50 Hz				84	27	3.11	0.983	83
1000V	300 Hz				84	25	3.36	0.983	83
1000V (3)	20 kHz				131	27	4.85	1.000	131
1000V (3)	30 kHz				371	60	6.18	1.000	371
1000V (3)	40 Hz				84	27	3.11	0.983	84

1: This is a test of the bottom of the 20V range and will require re-referencing at 2.3V dc.

2: Observe the 5700A/5720A Series II output for 10 minutes and verify that it remains within ±7.5 ppm. Return to 1 kHz and algebraically subtract from the reading any drift from the 792A.

3: Perform only for units that are used with a 5725A Amplifier.

4: When the TUR (Test Uncertainty Ratio) is less than 4:1, the spec is reduced to give the same Consumer Risk as a 4:1 TUR as described later in this chapter.

Table 3-32. AC Voltage 2 mV Range Test Record

Characterized 1.9 mV Reading	Error Display Reading	Limits
		±0.26%

Table 3-33. 5720A AC Current 20 mA to 10A (792A)

Output Current	Frequency	A40 Shunt ac-dc Difference ± ppm	UUT Error Display ± ppm	Calculated Error ± ppm	Spec (± ppm) (90-day)	5790A Transfer Spec/ Rss With A40 ± ppm (1)	TUR	GB Limit	Test Limit (± ppm)
2A	40 Hz				320	106	3.02	0.981	314
2A	1 kHz				320	106	3.02	0.981	314
2A	5 kHz				510	106	4.81	1.000	510
2A	10 kHz				7100	125	56.80	1.000	7100
200 mA	10 Hz				305	375	0.81	0.926	179
200 mA	20 Hz				200	124	1.61	0.895	179
200 mA	40 Hz				145	57	2.54	0.964	140
200 mA	1 kHz				145	57	2.54	0.964	140
200 mA	5 kHz				240	124	1.94	0.964	140
200 mA	10 kHz				1160	124	9.35	1.000	1160
20 mA	10 Hz				305	375	0.81	.926	179
20 mA	20 Hz				200	124	1.61	0.895	179
20 mA	40 Hz				150	57	63	.967	145
20 mA	1 kHz				150	57	63	.967	145
20 mA	5 kHz				255	124	2.06	0.936	239
20 mA	10 kHz				1400	124	11.29	1.000	1400
10A (2)	40 Hz				417	131	3.18	0.985	411
10A (2)	1 kHz				417	131	3.18	0.985	888
10A (2)	5 kHz				888	172	5.16	1.000	888
10A (2)	10 kHz				3375	172	19.62	1.000	3375

1: The 5790A 1 year specs RSS (root-sum-square) with the A40 uncertainty, and the DC uncertainty.

2: If a 5725A is attached.

Table 3-34. 5700A AC Current 20 mA to 10A (5790A)

Output Current	Frequency	A40 Shunt ac-dc Difference ± ppm	UUT Error Display ± ppm	Calculated Error ± ppm	Spec (± ppm) (90-day)	5790A Transfer Spec/ Rss With A40 ± ppm (1)	TUR	GB Limit	Test Limit (± ppm)
2A	40 Hz				670	106	6.32	1.000	670
2A	1 kHz				670	106	6.32	1.000	670
2A	5 kHz				800	106	7.55	1.000	800
2A	10 kHz				9100	125	72.80	1.000	9100
200 mA	10 Hz				725	375	1.93	0.928	394
200 mA	20 Hz				400	124	3.23	0.986	167
200 mA	40 Hz				170	57	2.98	0.980	167
200 mA	1 kHz				170	57	2.98	0.980	850
200 mA	5 kHz				850	124	6.85	1.000	850
200 mA	10 kHz				2100	124	16.94	1.000	2100
20 mA	10 Hz				725	375	1.93	0.928	394
20 mA	20 Hz				400	124	3.23	0.986	156
20 mA	40 Hz				160	57	2.81	0.974	1576
20 mA	1 kHz				160	57	2.81	0.979	8506
20 mA	5 kHz				850	124	6.85	1.000	850
20 mA	10 kHz				2100	124	16.94	1.000	2100
10A (2)	40 Hz				417	131	3.18	0.985	411
10A (2)	1 kHz				417	131	3.18	0.985	888
10A (2)	5 kHz				888	172	5.16	1.000	888
10A (2)	10 kHz				3375	172	19.62	1.000	3375

1: The 5790A 1 year specs RSS (root-sum square) with the A40 uncertainty, and the DC uncertainty.

2: If a 5725A is attached.

Table 3-35. AC Current 20 mA to 10A Accuracy Test Record (5720A)

2A, 200 mA, 20 mA and 10A Test Record					
Output Current	**Freq**	**A40 Shunt AC-DC Diff**	**UUT Error Display**	**Calculated Error**	**Spec ± ppm**
2A	40 Hz				320
2A	1 kHz				320
2A	5 kHz				510
2A	10 kHz				7100
200 mA	10 Hz				305
200 mA	20 Hz				200
200 mA	40 Hz				145
200 mA	1 kHz				145
200 mA	5 kHz				240
200 mA	10 kHz				1160
20 mA	10 Hz				305
20 mA	20 Hz				200
20 mA	40 Hz				150
20 mA	1 kHz				150
20 mA	5 kHz				255
20 mA	10 kHz				1400
10A (1)	40 Hz				417
10A (1)	1 kHz				417
10A (1)	5 kHz				888
10A (1)	10 kHz				3375

1: If a 5725A is attached.

Table 3-36. AC Current 20 mA to 10A Accuracy Test Record (5700A)

2A, 200 mA, 20 mA and 10A Test Record (10A Only for 5725A)					
Output Current	**Freq**	**A40 Shunt AC-DC Diff**	**UUT Error Display**	**Calculated Error**	**Specs ±ppm**
2A	40 Hz				670
2A	1 kHz				670
2A	5 kHz				800
2A	10 kHz				9100
200 mA	10 Hz				725
200 mA	20 Hz				400
200 mA	40 Hz				170
200 mA	1 kHz				170
200 mA	5 kHz				850
200 mA	10 kHz				2100
20 mA	10 Hz				725
20 mA	20 Hz				400
20 mA	40 Hz				160
20 mA	1 kHz				60
20 mA	5 kHz				850
20 mA	10 kHz				2100
10A (1)	40 Hz				417
10A (1)	1 kHz				417
10A (1)	5 kHz				888
10A (1)	10 kHz				3375
1: If a 5725 is attached.					

Table 3-37. 5720A AC Current 2 mA and 200 µA Accuracy Test Record (5790A)

Output Current	Frequency	Error	Spec. ± ppm (90-day)	5790A Transfer Spec ± ppm	TUR	GB Factor	Test Limits ± ppm
2 mA	10 Hz		305	210	1.45	0.874	267
2 mA	20 Hz		200	73	2.74	0.971	194
2 mA	40 Hz		150	27	5.56	1.000	150
2 mA	1 kHz		150	27	5.56	1.000	150
2 mA	5 kHz		285	27	10.56	1.000	285
2 mA	10 kHz		1500	27	55.56	1.000	1500
200 µA	10 Hz		380	210	1.81	0.916	348
200 µA	20 Hz		240	73	3.29	0.988	237
200 µA	40 Hz		180	27	6.67	1.000	180
200 µA	1 kHz		180	27	6.67	1.000	180
200 µA	5 kHz		395	27	14.63	1.000	+365/-425 (1)
200 µA	10 kHz		1500	27	55.56	1.000	+1380/-1620 (1)

1: The spec is modified because of the capacitive loading of the 2K resistor by the cable and input of the 5790A.

Table 3-38. 5700A AC Current 2 mA and 200 µA Accuracy Test Record (5790A)

Output Current	Frequency	Error	Spec ± ppm (90-day)	5790A Transfer Spec ± ppm	TUR	GB Factor	Test Limits ± ppm
2 mA	10 Hz		725	210	3.45	0.991	718
2 mA	20 Hz		400	73	5.48	1.000	400
2 mA	40 Hz		160	27	5.93	1.000	160
2 mA	1 kHz		160	27	5.93	1.000	160
2 mA	5 kHz		850	27	31.48	1.000	850
2 mA	10 kHz		2100	27	77.8	1.000	2100
200 µA	10 Hz		850	210	4.05	1.000	850
200 µA	20 Hz		505	73	6.92	1.000	505
200 µA	40 Hz		240	27	8.89	1.000	240
200 µA	1 kHz		240	27	8.89	1.000	240
200 µA	5 kHz		850	27	31.48	1.000	+820/-880 (1)
200 µA	10 kHz		2100	27	77.8	1.000	+1980/-2220 (1)

1: The spec is modified because of the capacitive loading of the 2K resistor by the cable and input of the 5790A.

Table 3-39. 5720A AC Current 2 mA and 200 mA Accuracy Test Record (792A)

Frequency	2 mA AC Output UUT Error Display	Spec ± ppm
10 Hz		305
20 Hz		200
40 Hz		150
1 kHz		150
5 kHz		285
10 kHz		1500
Frequency	**200 µA AC Output UUT Error Display**	**Spec ± ppm**
10 Hz		380
20 Hz		240
40 Hz		180
1 kHz		180
5 kHz		395
10 kHz		1500

Table 3-40. 5700A AC Current 2 mA and 200 mA Accuracy Test Record (792A)

Frequency	2 mA AC Output UUT Error Display	Spec ± ppm
10 Hz		725
20 Hz		400
40 Hz		160
1 kHz		160
5 kHz		850
10 kHz		2100
Frequency	**2 mA AC Output UUT Error Display**	**Spec ± ppm**
10 Hz		850
20 Hz		505
40 Hz		240
1 kHz		240
5 kHz		850
10 kHz		2100

Table 3-41. Wideband Frequency Accuracy Test Record

Frequency (Hz)	Frequency Measured	Tolerance Limits
10 Hz		99.99 ms to 100.01 ms
100 Hz		9.999 ms to 10.001 ms
300 Hz		299.97 Hz to 300.03 Hz
500 Hz		499.95 Hz to 500.05 Hz
800 Hz		799.92 Hz to 800.08 Hz
900 Hz		899.91 Hz to 900.09 Hz
1 kHz		999.0 Hz to 1.0001 kHz
1.19 kHz		1.189881 kHz to 1.190119 kHz
2.2 MHz		2.19978 MHz to 2.20022 MHz
3.5 MHz		3.49965 MHz to 3.50035 MHz
3.8 MHz		3.79962 MHz to 3.80038 MHz
10 MHz		9.990 MHz to 10.001 MHz
20 MHz		19.998 MHz to 20.002 MHz
30 MHz		29.997 MHz to 30.003 MHz

Table 3-42. Wideband Accuracy at 1 kHz Test Record (5790A)

Output Level	Measured Error	Spec ± ppm (90-day)	5790A 1-Year Spec ± ppm	TUR	GB Factor	Test Limit
2.1V		2238	24	93	1.000	2238
1.0V		2900	24	121	1.000	2900
0.3V		2833	38	74.5	1.000	2833
0.1V		3400	53	64.1	1.000	3400
30 mV		3333	115	29.0	1.000	3333
10 mV		3900	240	16.2	1.000	3900
3 mV		4833	643	7.5	1.000	4833
1 mV		5400	1720	3.14	0.980	5292

Table 3-43. Wideband Flatness Test Record

Output Level	Frequency	Measured Flatness Error	Spec ± ppm (90-day)	5790A 1-Year Spec	TUR	GB Factor	Test Limit ± ppm
3V	10 Hz		3000	1000	3.00	0.980	2940
	30 Hz		1000	300	3.33	0.988	988
	10 kHz		1000	300	3.33	0.988	988
	120 kHz		1000	300	3.33	0.988	988
	500 kHz		1000	300	3.33	0.988	988
	2 MHz		1000	500	2.00	0.932	932
	5 MHz		2000	1000	2.00	0.932	1864
	10 MHz		2000	1000	2.00	0.932	1864
	20 MHz		4000	1500	2.67	0.968	3872
	30 MHz		10000	3500	2.86	0.975	9750
1V	10 kHz		1000	300	3.33	0.988	988
	120 kHz		1000	300	3.33	0.988	988
	500 kHz		1000	300	3.33	0.988	988
	2 MHz		1000	500	2.00	0.932	932
	5 MHz		2000	1000	2.00	0.932	1864
	10 MHz		2000	1000	2.00	0.932	1864
	20 MHz		4000	1500	2.67	0.968	3872
	30 MHz		10000	3500	2.86	0.975	9750
300 mV	10 kHz		1000	300	3.33	0.988	988
	120 kHz		1000	300	3.33	0.988	988
	500 kHz		1000	300	3.33	0.988	988
	2 MHz		1000	500	2.00	0.932	932
	5 MHz		2000	1000	2.00	0.932	1864
	10 MHz		2000	1000	2.00	0.932	1864
	20 MHz		4000	1500	2.67	0.968	3872
	30 MHz		10000	3500	2.86	0.975	9750
100 mV	10 kHz		1000	400	2.50	0.961	961
	120 kHz		1000	400	2.50	0.961	961
	500 kHz		1030	400	2.58	0.964	993
	2 MHz		1030	500	2.06	0.936	964
	5 MHz		2030	1000	2.03	0.933	2176
	10 MHz		2030	1000	2.03	0.933	1894
	20 MHz		4030	1500	2.69	0.970	1864
	30 MHz		10030	3500	2.87	0.976	9789

Table 3-43. Wideband Flatness Test Record (cont)

Output Level	Frequency	Measured Flatness Error	Spec ± ppm (90-day)	5790A 1-Year Spec	TUR	GB Factor	Test Limit ± ppm
30 mV	10 kHz		1000	500	2.00	0.932	932
	120 kHz		1000	500	2.00	0.932	932
	500 kHz		1100	500	2.20	0.945	945
	2 MHz		1100	500	2.20	0.945	1040
	5 MHz		2100	1000	2.10	0.939	1972
	10 MHz		2100	1000	2.10	0.939	1972
	20 MHz		4100	1500	2.73	0.972	3985
	30 MHz		10100	3500	2.89	0.977	9868
10 mV	10 kHz		1000	500	2.00	0.932	932
	120 kHz		1000	500	2.00	0.932	932
	500 kHz		1300	700	1.86	0.920	1196
	2 MHz		1300	700	1.86	0.920	1196
	5 MHz		2300	1000	2.30	0.950	2185
	10 MHz		2300	1000	2.30	0.950	2185
	20 MHz		4300	1700	2.53	0.962	4137
	30 MHz		10300	3700	2.78	0.972	10012
3 mV	10 kHz		1000	500	2.00	0.932	932
	120 kHz		1000	500	2.00	0.932	932
	500 kHz		2000	1033	1.94	0.928	1856
	2 MHz		2000	1033	1.94	0.928	1856
	5 MHz		4000	1333	3.00	0.980	4082
	10 MHZ		4000	1333	3.00	0.980	3920
	20 MHz		6000	2033	2.95	0.978	5868
	30 MHz		16000	4033	3.97	0.999	15984
1 mV	10 kHz		1000	500	2.00	0.932	932
	120 kHz		1000	500	2.00	0.932	932
	500 kHz		5000	1700	2.94	0.978	4890
	2 MHz		5000	1700	2.94	0.978	4890
	5 MHZ		7000	2700	2.59	0.965	6755
	10 MHz		7000	2700	2.59	0.965	6755
	20 MHz		9000	4000	2.25	0.948	8532
	30 MHz		30000	9000	3.33	0.988	29640

Table 3-44. Wideband Absolute Error 10 Hz to 500 kHz

Output Level	Frequency	1 kHz Absolute Error ppm	Flatness Error ppm	Error Sum ppm	90-Day Spec Limit (±ppm)
2.1V	10 Hz				5238
	30 Hz				2238
	10 kHz				2238
	120 kHz				2238
	500 kHz				2238
1V	10 kHz				2900
	120 kHz				2900
	500 kHz				2900
300 mV	10 kHz				2833
	120 kHz				2833
	500 kHz				2833
100 mV	10 kHz				3400
	120 kHz				3400
	500 kHz				3400
30 mV	10 kHz				3333
	120 kHz				3333
	500 kHz				3333
10 mV	10 kHz				3900
	120 kHz				3900
	500 kHz				3900
3 mV	10 kHz				4833
	120 kHz				4833
	500 kHz				4833
1 mV	10 kHz				5400
	120 kHz				5400
	500 kHz				5400

Table 3-45. Wideband Accuracy at 1 kHz Test Record (792A)

Output Level	DC DMM Reading of 5700A/5720A Series II Main Output	Wideband Output Error Display Reading	Spec ±%
3.0V			0.22
1.0V			0.29
0.3V			0.28
0.1V			0.34
30 mV			0.33
10 mV			0.39
3 mV			0.48
1 mV			0.54

Table 3-46. Output Flatness and Attenuator Flatness Test Record (792A)

Frequency	50Ω Detector Characterization RMS Wideband DC DMM Reading	3V Range Wideband Flatness Test Error Reading	Spec	792 Uncert.	Test Limit
1 kHz	0.90000V	—	—	—	
10 Hz			0.3%	> 4:1	0.3%
30 Hz			0.1%	0.05%	0.08%
120 kHz			0.1%	0.05%	0.08%
500 kHz			0.1%	0.05%	0.08%
2 MHz			0.1%	0.05%	0.08%
5 MHz			0.2%	0.1%	0.17%
10 MHz			0.2%	0.1%	0.17%
20 MHz			0.4%	0.15%	0.37%
30 MHz			1.0%	> 4:1	1.0%

Attenuator Flatness Test Record

Freq	Wideband DC DMM Char Data	(60 dB) 1.0V Output	(50 dB) 300 mV Output	(40 dB) 100 mV Output	(30 dB) 30 mV Output	(20 dB) 10 mV Output	>3 mV Limit	Reduced Limit	(10 dB) 3 mv Output	3 mV Limit	(0 db) 1 mV Output	1 mV Limit
1 kHz	0.90000V	0.90000V	0.90000V	0.90000V	0.90000V	0.90000V			0.90000V		0.90000V	
500 kHz							0.1%+3μV			0.2%		0.5%
2 MHz							0.1%+3μV			0.2%		0.5%
10 MHz							0.2%+3μV	0.17%		0.4%		0.7%
20 MHz							0.4%+3μV	0.37%		0.6%		0.9%
30 MHz							1%+3μV			1.6%		3.0%
1 kHz	<0.02%^	<0.02%^	<0.02%^	<0.02%^	<0.02%^	<0.02%^			<0.02%^		<0.02%^	

Table 3-47. Load Regulation Test Record

Div. Setting	5700A/5720A Series II Range	5700A/5720A Series II Out/Full Load	Change In Null Measured	Change In Null Limit
10V	11V	10V/199Ω		±2 μV
100V	220V	100V/1999Ω		±2 μV
1000V	1100V	1000V/49.99 kΩ		±2 μV

Table 3-48. DC Voltage Linearity Test Record

Kelvin-Varley Setting	5700A/5720A Series II Output	Null Detector Reading	Null Detector Reading limit
0.1	1V		±2.3 μV
0.2	2V		±2.6 μV
0.3	3V		±2.9 μV
0.4	4V		±3.2 μV
0.5	5V		±3.5 μV
0.6	6V		±3.8 μV
0.7	7V		±4.1 μV
0.8	8V		±4.4 μV
0.9	9V		±4.7 μV

Table 3-49. DC Voltage Output Noise Test

Differential Amplifier Sensitivity	Calibrator (UUT)	Rms Meter Reading	Maximum rms Meter Reading
50 μV/division	2.2V		150 mV
50 μV/division	10V		500 mV
50 μV/division	20V		500 mV
100 μV/division	200V		750 mV
500 μV/division	1000V		500 mV

Table 3-50. AC V Distortion Test Summary

5700A/5720A Series II Output	Load Resistors	Frequency	Measured Distortion	Max. Distortion
2V	100Ω, 1/8W	10 Hz, 20 Hz		0.054%
		1 kHz, 20 kHz, 50 kHz,		0.044%
		100 kHz, 200 kHz, 500 kHz		0.355%
20V	1 kΩ, 1/2W	10 Hz, 20 Hz		0.0535%
		20 kHz, 100 kHz		0.0385%
		200 kHz, 500 kHz		0.304%
200V	10 kΩ, 5W	10 Hz, 20 Hz		0.055%
		50 kHz, 100 kHz		0.1065%
300V(1)	15 kΩ, 5W	40 Hz		0.1%
300V(1)	15 kΩ, 5W	50 kHz		0.3%
300V(1)	15 kΩ, 5W	70 kHz		0.4%

(1) The 5700A/5720A Series II maximum volt-Hertz product is (2.2 x 10^7) The 300V level assumes that a Fluke 5725A Amplifier is attached.

Table 3-51. Test Record for Flatness Check of the AC 2 mV Range

Frequency	UUT Error Display Reading	Limits
10 Hz		
20 Hz		±0.26%
40 Hz		
1 kHz		±0.26%
20 kHz		±0.29%
50 kHz		±0.49%
100 kHz		±0.87%
300 kHz		
500 kHz		±1.83%
1 MHz		

Table 3-52. Alternate AC Voltage Millivolt Ranges Test Record

1 KHZ Level Verification (200 mV and 20 mV Ranges)			
UUT Output	**Ratio Trans Setting**	**931 200 mV Reading**	**931 20 mV Reading**
2V @ 1 kHz	0.1	N/A	N/A
2V @ 1 kHz	0.01		
UUT Output	**UUT Error Display**	**Limits**	
200 mV @ 1 kHz		±150 ppm	
20 mV @ 1 kHz		±410 ppm	
Frequency Response Testing (200 mV and 20 mV Ranges)			
Characterizing 200 mV LEVEL of RMS Diff. Voltmeter:			
Freq.	**RMS Diff. Voltmeter Reading**		
1 kHz	Null		
40 Hz			
20 kHz			
50 kHz			
100 kHz			
300 kHz			
1 MHz			
1 kHz	Return to Null ±0.003%		

Table 3-52. Alternate AC Voltage Millivolt Ranges Test Record (cont)

Characterizing 20 mV Level of RMS Diff. Voltmeter:

Freq.	RMS Diff. Voltmeter Reading
1 kHz	Null
40 Hz	
20 kHz	
50 kHz	
100 kHz	
300 kHz	
1 MHz	
1 kHz	Return to Null ±0.01%

20 mV Output Accuracy:

Freq.	UUT Error Display	Limits	
10 Hz		±850 ppm	
20 Hz		±520 ppm	
20 kHz		±410 ppm	
50 kHz		±670 ppm	
100 kHz		±0.13%	
300 kHz		±0.195%	
1 MHz		±0.48%	

200 mV Output Accuracy:

Freq.	UUT Error Display	Limits	
10 Hz		±630 ppm	
20 Hz		±270 ppm	
40 Hz		±150 ppm	
20 kHz		±150 ppm	
50 kHz		±380 ppm	
100 kHz		±0.115%	
300 kHz		±0.19%	
1 MHz		±0.38%	

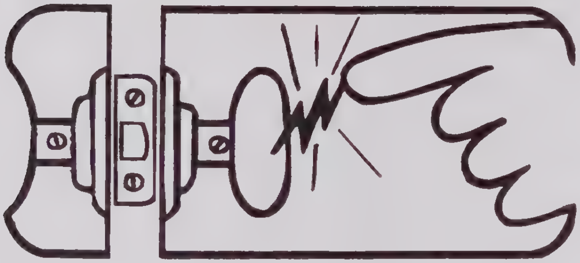
Table 3-53. Alternate 2 mA and 200 mA AC Current Test

DMM 2 mA DC Reading =		
Corrected 2 mA DC Voltage =		
Expected 2 mA AC Reading (Voltage)	**Actual 2 mA Error (ppm)**	**Spec (±ppm)**
10 Hz =		725
20 Hz =		400
40 Hz =		160
1 kHz =		160
5 kHz =		850
10 kHz =		2100
DMM 200 µA DC Reading =		
Corrected 200 µA DC Voltage =		
EXPECTED 200 mA AC Reading (Voltage)	**Actual 200 µA Error (in Percent)**	**Spec (±ppm)**
10 Hz =		850
20 Hz =		505
40 Hz =		240
1 kHz =		240
5 kHz =		5750
10 kHz =		24,400

static awareness

A Message From

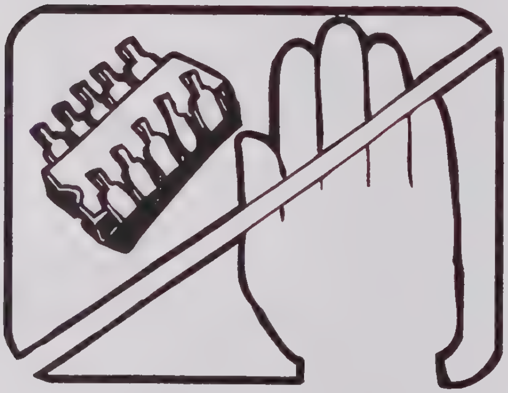
Fluke Corporation



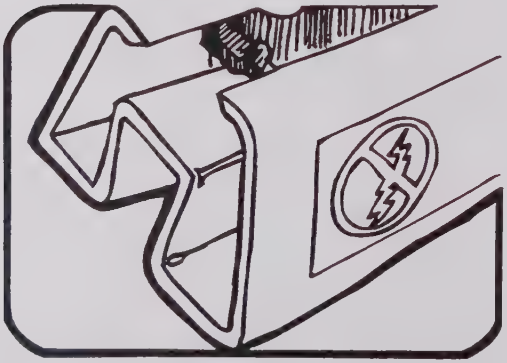
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Leaning the guidelines for handling them.
3. Using the procedures, packaging, and bench techniques that are recommended.

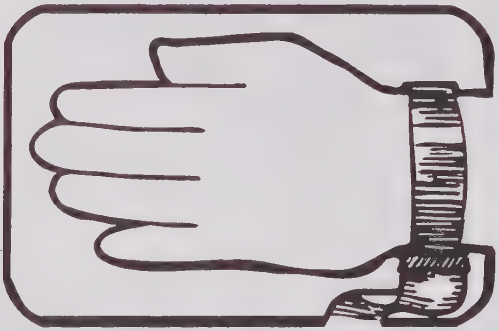
The following practices should be followed to minimize damage to S.S. (static sensitive) devices.



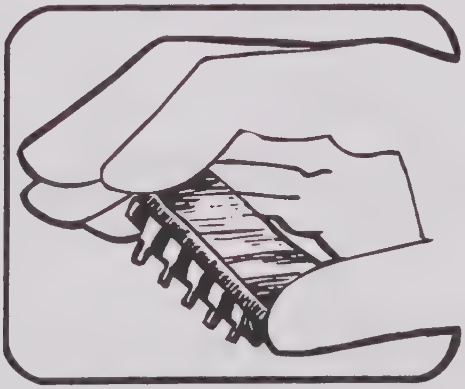
1. MINIMIZE HANDLING



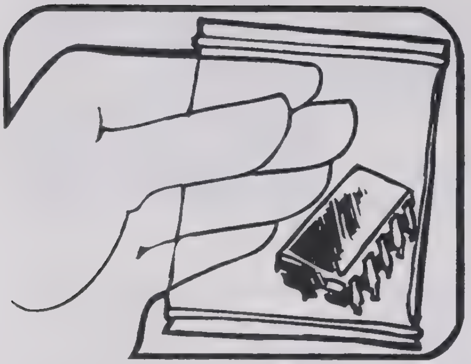
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



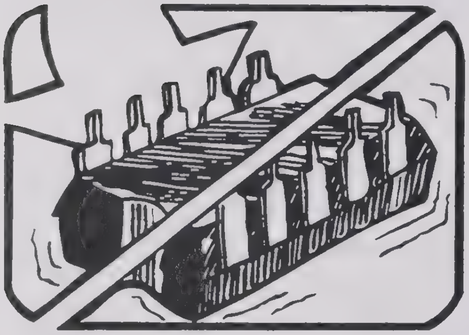
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



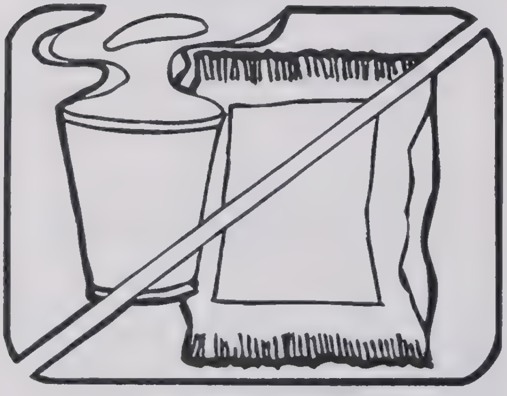
4. HANDLE S.S. DEVICES BY THE BODY.



5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT.



6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE.



7. AVOID PLASTIC,VINYL AND STYROFOAM® IN WORK AREA.

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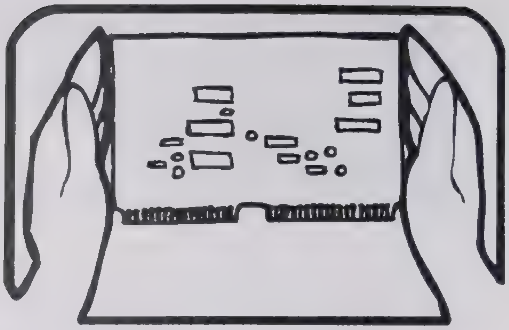
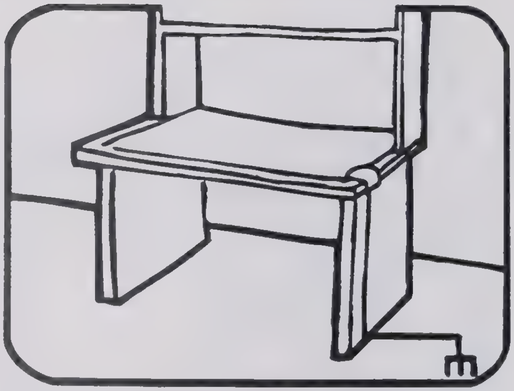


8. WHEN REMOVING PLUG-IN ASSEMBLIES HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS PROTECT INSTALLED S.S. DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION.

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED-TIP SOLDERING IRONS SHOULD BE USED.

Chapter 4
Maintenance

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Introduction 4-1.

This section covers procedures that do not fall into the category of troubleshooting or repair. This includes access procedures, installation of the Wideband module (Option -03), periodic cleaning, and other special service procedures.

Cleaning the Air Filter 4-2.

Caution

Damage caused by overheating may occur if the area around the fan is restricted, the intake air is too warm, or the air filter becomes clogged.

The air filter must be removed and cleaned every 30 days or more frequently if the calibrator is operated in a dusty environment. The air filter is accessible from the rear panel of the calibrator.

To clean the air filter, refer to Figure 4-1 and proceed as follows:

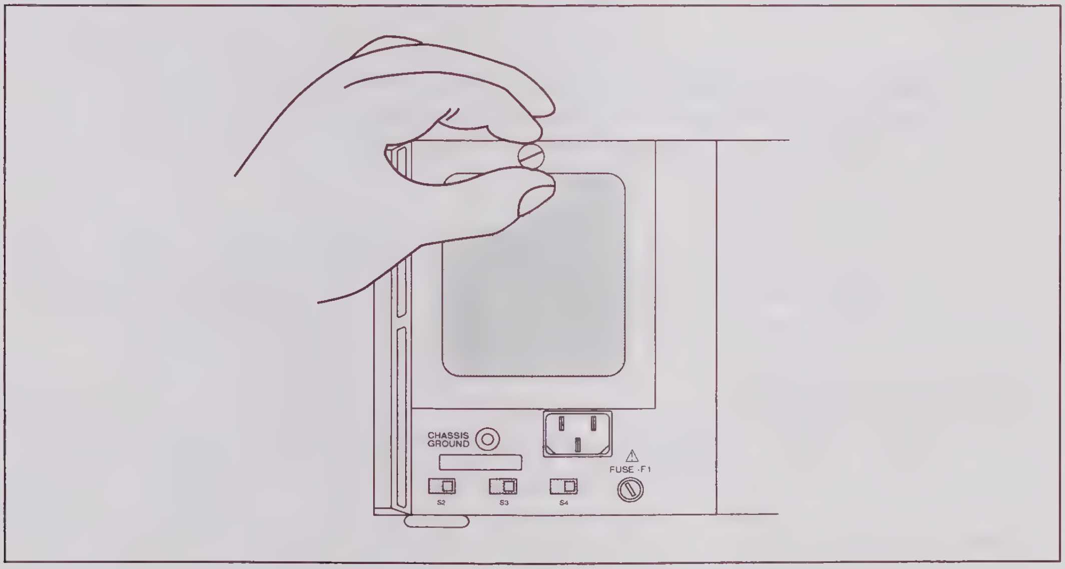


Figure 4-1. Air Filter

1. Remove the filter element.
    a. Unscrew the knurled screw at the top of the air filter (counterclockwise).
    b. Pull the air filter retainer downward; it hinges at the bottom.
    c. Remove the filter element.
2. Clean the filter element.
    a. Wash the filter element in soapy water.
    b. Rinse the filter element in fresh running water.
    c. Shake out the excess water, then allow the filter element to dry thoroughly before reinstalling it.

3. Reinstall the filter element, its retainer, and the knurled screw.

General Cleaning 4-3.

To keep the Calibrator looking like new, clean the case, front panel keys, and lens using a soft cloth slightly dampened with water or a non-abrasive mild cleaning solution that does not harm plastics.

Caution

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They can damage the plastic materials used in the calibrator.

Cleaning PCA's 4-4.

Printed circuit assemblies only need cleaning after repair work. After soldering on a pca, remove flux residue using isopropyl alcohol and a cotton swab.

Access Procedures 4-5.

Warning

Servicing described in this section is to be performed by qualified service personnel only. To avoid electrical shock, do not perform any servicing unless qualified to do so.

Top and Bottom Covers 4-6.

Check that power is not connected to the Calibrator; the power control must be off, and the line power cord must be disconnected. Top and bottom covers are each secured with eight Phillips head screws (four front, four rear).

Digital Section Cover 4-7.

The Digital Section is accessed through one top cover that is secured by six Phillips head screws.

Analog Section Covers 4-8.

The Analog Section is enclosed with separate covers on top and bottom. The top cover is secured with seven Phillips head screws. The bottom Analog Section cover is secured with eight Phillips head screws (three short, five longer).

Rear Panel Removal and Installation 4-9.

Detach the Rear Panel by removing the six hex head screws (three on each rear handle side) and the two Phillips head screws found along the side of the Fan Assembly. Refer to Figure 4-2 for screw locations.

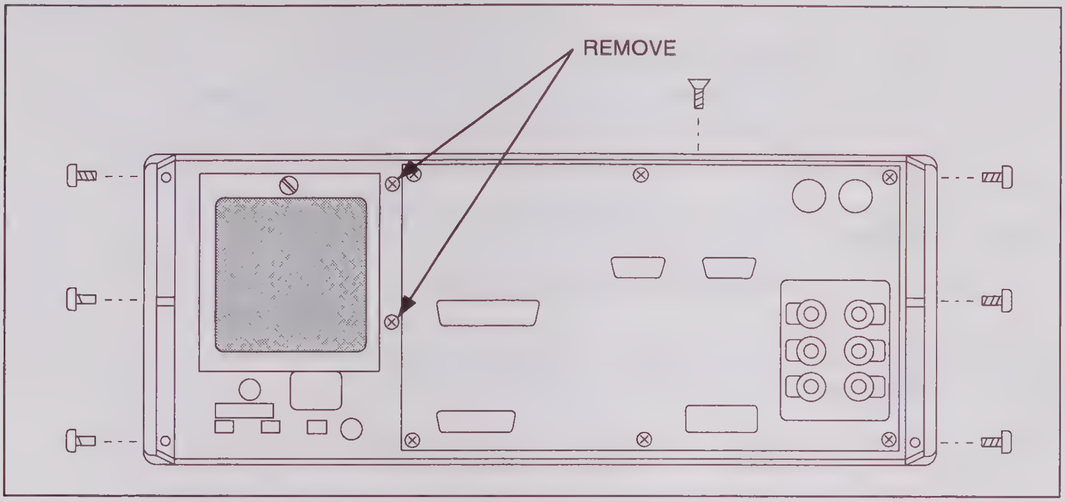
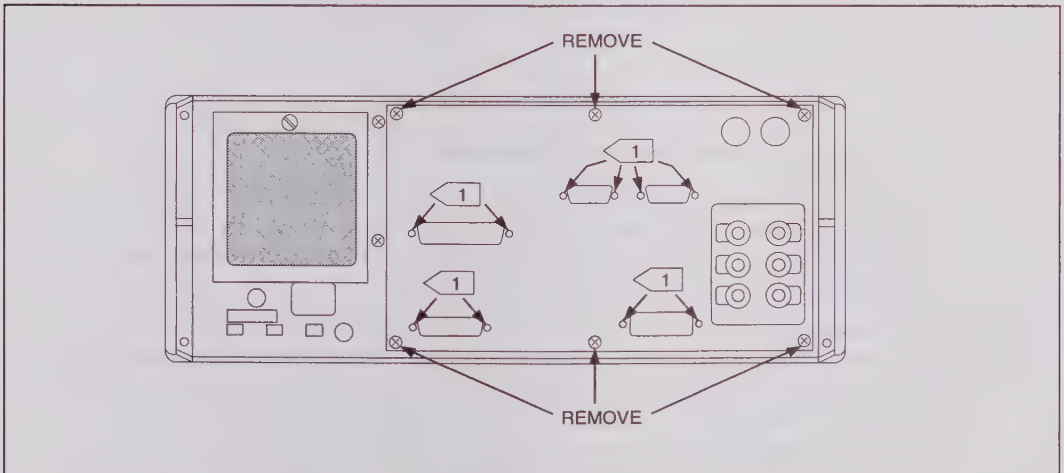


Figure 4-2. Rear Panel Removal

Rear Panel Assembly Access *4-10.*

Refer to Figure 4-3 during the following procedure:



REMOVE FACK SCREWS TO SEPARATE THE REAR PANEL CIRCUIT BOARD FROM THE METAL HOUSING.

Figure 4-3. Rear Panel Assembly Access

1. Remove the six securing screws for the Rear Panel assembly housing.
2. Gently pull the rear panel housing from the Rear Panel.
3. Allow the rear panel housing to lay flat on the work surface by removing the two ribbon cables from the Rear Panel board.
4. Remove the two nuts at TB1 and TB2 on the paddle board; separate the associated wires from the paddle board.

5. Remove P11 from J11. Then remove the two paddle board mounting screws and separate the paddle board from the Rear Panel assembly.
6. Remove the jack screws for each connection on the rear panel housing, then gently lift the Rear Panel assembly out from the housing.
7. Reverse this procedure to install the Rear Panel assembly.

Front Panel Removal and Installation 4-11.

Refer to Figure 4-4 during the following procedure:

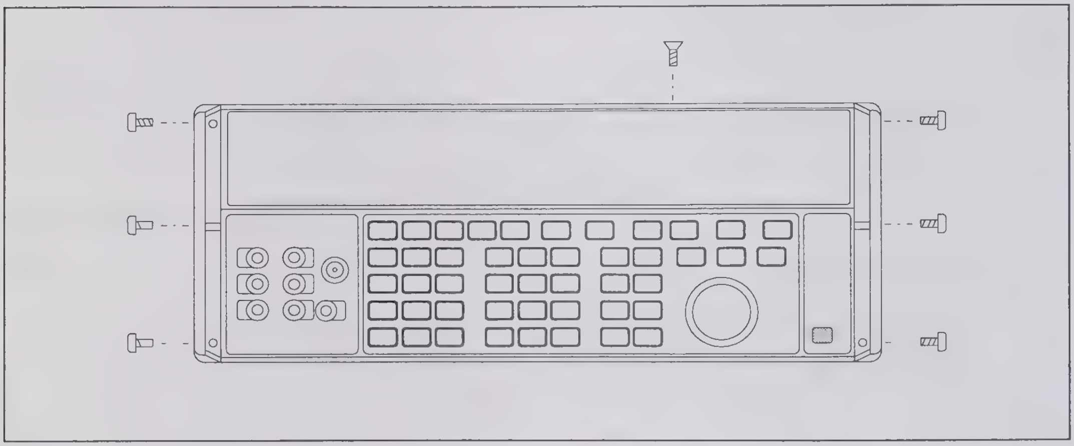


Figure 4-4. Front Panel Removal

1. Remove the Calibrator top and bottom covers.
2. Remove the single screw at the top of the Front Panel and the six hex screws on the front handle sides. Then grasp both handles and gently tilt the Front Panel down and away from the mainframe, disengaging the green power button. Position the Front Panel on its handles, in front of the instrument.
3. If you need to completely detach the Front Panel from the Calibrator, one, or possibly two, cables must be disconnected. The output cable must be detached in all configurations. If the Wideband Option is installed, you must also detach the related connector from the Front Panel.

Reverse this procedure to install the Front Panel.

Display Assembly Removal and Installation 4-12.

Once the Front Panel has been removed, use the following procedure to access the Display assembly.

1. Remove the ribbon cable connecting the Display assembly to the Motherboard.
2. Remove the six screws securing the Front Panel Display assembly cover shield. Three of these screws are accessed from the inside, and the other three are accessed along the top of the front panel.
3. Remove the seven screws securing the Front Panel Display assembly to the Front Panel. Gently lift the Front Panel Display assembly up, and remove the keyboard ribbon cable. Now remove the Front Panel Display assembly.

Reverse this procedure to install the Front Panel Display assembly.

Keyboard Assembly Removal and Installation *4-13.*

The following procedure assumes that the Display Assembly Removal procedure has already been completed.

1. Remove all output cable connections (including GROUND-to-metal) from the front panel binding posts. Save all removed hardware.
2. Remove the two hex screws at the front of each handle. Then remove the front handles.
3. Gently release the eight plastic hook catches, and separate the front panel plastic from the sheet metal.
4. Remove the output adjustment knob flywheel by taking out its center screw. Hold the wheel in place by inserting a pencil in one of the flywheel holes and pressing on one of the plastic standoffs.
5. Remove the nine self-tapping screws connecting the Keyboard assembly to the front panel plastic.
6. Remove the Keyboard assembly by gently releasing the seven plastic hook catches. Work from one side of the board to the other. Start at either side by simultaneously releasing a catch and lifting on the board.

Reverse this procedure to install the Keyboard assembly. When reconnecting the wires to the binding posts, be sure to include a washer on each side of the ring terminals. Refer to the nearby decal or see sheet 4 of the Analog Motherboard schematic in Section 8 of this manual for proper connection of the output cable to the front binding posts.

Caution

Do not tighten the nuts that hold the wires to the binding posts more than 7 in-lb. Force exceeding 7 in-lb can destroy the binding posts.

Analog Assembly Removal and Installation *4-14.*

The analog assemblies are installed in the sequence shown in Figure 4-5. Note that each module cannot be positioned in any other slot and that identifying information on the tab for each module faces forward. In most cases, the component side of each module also faces forward. The component side faces to the rear for three modules: Current/High Resolution Oscillator (A7), Ohms Cal (A9), and High Voltage Control (A14). All modules except the High Voltage Control pull straight up to disengage from the Digital Motherboard. For the High Voltage Control module, two Phillips head captive screws at the outer corners of the High Voltage Transformer must be removed before the module can be removed.

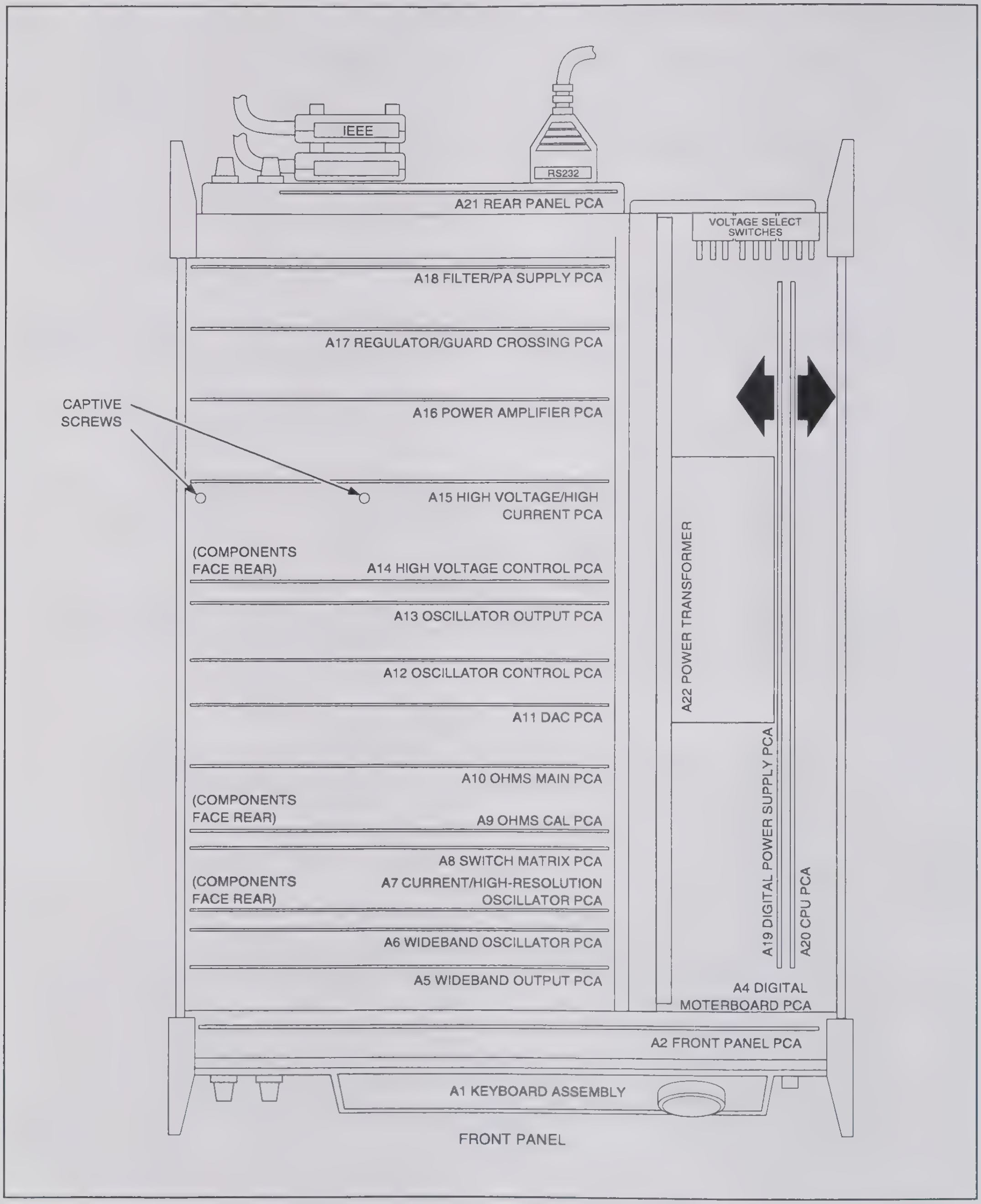


Figure 4-5. Analog and Digital Assemblies

Caution

Do not touch any circuit area on an analog assembly. Contamination from skin oil can produce high resistance paths, with resulting leakage currents and possible erroneous readings. Always grasp an analog assembly by its upper corner ears.

Digital Assembly Removal and Installation 4-15.

Remove the CPU Assembly or the Digital Power Supply Assembly by pulling straight up at the top corners of the assembly. In relation to the chassis side, the CPU Assembly components face toward, and the Digital Power Supply Assembly components face away. See Figure 4-5.

Power Transformer Removal and Installation 4-16.

Use the following procedure to remove the Power Transformer assembly:

1. Remove the Calibrator Front and Rear Panels.
2. Remove the Digital Power Supply (A19) and CPU (A20) assemblies.
3. Detach the five connectors leading from the Power Transformer assembly to the Digital Motherboard. The three connectors at the rear of the assembly may not be accessible without first removing the rear fan. With the two digital assemblies (A19 and A20) removed, the four Phillips head screws securing this fan can be accessed through holes in the chassis side.

   Note that no two Power Transformer connectors are the same size and that each connector is keyed; re-connection only involves matching appropriate connectors.
4. Working from the bottom of the instrument, remove the Digital Motherboard (A4) assembly.
5. Remove the eleven screws securing the Power Transformer assembly, as follows:
   - Rear Panel: two screws, which were removed along with the Rear Panel.
   - Front Panel: two screws.
   - Top Edge: four screws.
   - Bottom Edge: three screws.
6. Remove the Power Transformer assembly.

To install the Power Transformer assembly, reverse the preceding six steps.

Hybrid Cover Removal 4-17.

When removing the plastic covers from the hybrid assemblies, push the ends of the cover retainer pins through from the back of the circuit board. The retainer pins can be damaged by attempting to pull the covers off.

Front/Rear Binding Post Reconfiguration 4-18.

An internal cable can be configured for output connections at either the front or rear binding posts. The front binding posts are usually connected at the factory. If the rear binding posts are connected at the factory, a decal describing this arrangement is attached to the front binding posts. The procedure that follows can be used to swap an existing binding post configuration; it is to be done only at Service Centers. The following procedure can be used to change front-to-rear or rear-to-front.

Reverse this procedure when changing from rear to front output operation.

1. Remove instrument top and bottom covers and remove bottom analog guard cover.
2. Remove the instrument front panel by removing the three hex screws on each front handle side and a single screw on the top of the front panel. See Figure 4-4 for screw locations. By grasping the handles gently pull the front panel away from the frame and lay it on its handles in front of the instrument.
3. Remove all the wires connecting the ring terminals of the output cable to the front panel binding posts. Save all hardware removed during this step.
4. Remove the two screws and restraining board attaching the toroid to the Front Panel. Save these items.
5. Position the output cable and toroid along the bottom left side of the instrument. In a later step, the output cable will be positioned between the Analog Motherboard and the left side panel.
6. Install the Front Panel.
7. Detach the Rear Panel by removing six hex screws (three on each rear handle side) and two screws near the the fan filter on the Rear Panel. See Figure 4-2 for screw locations. Then grasp the handles and gently pull the Rear Panel away from the frame.
8. Orient the instrument so that it is resting on its right side panel, with its bottom facing you.
9. Route the output cable between the left side panel and the Analog Motherboard, ending at the Rear Panel.
10. Using the items obtained during toroid removal, attach the toroid to the two rear panel standoffs.
11. Attach the color-coded output leads to the rear output binding posts. Use one washer on each side of each connecting ring. Verify connections by checking the decal mounted nearby or by matching lead color to the color on the front of the binding post. (Of the eleven wires, four are clear-insulated shield wires. If necessary, refer to page 4 of the Analog Motherboard schematic in Section 8 to determine these connections.)

   Caution

   Do not over tighten hardware on the binding posts. Torque in excess of seven inch-pounds can damage a binding post.

   Note that the I GUARD terminal is not connected at the front binding posts; cut away the I GUARD thermal fit covering to connect this terminal at the rear binding posts. Also, the AUX CURRENT ring terminal is not connected at the rear binding posts; this terminal must be insulated and tied off.

12. Replace the rear panel back, the bottom guard cover, and top and bottom covers to complete this procedure.

Installing a Wideband AC Module (Option -03) 4-19.

Caution

The Wideband option circuit board assemblies contain static-sensitive components. Use caution to avoid static discharge when handling the modules.

The procedure that follows can be used to install a 5700A-03 Wideband AC Voltage module in a Calibrator. The option consists of two circuit board assemblies. This procedure is to be done only at Service Centers.

1. Remove the top and bottom covers and analog section cover. (See ACCESS PROCEDURES this section)
2. Referring to Figure 4-5, locate the slots for the Wideband Output Module (A5) and the Wideband Oscillator Module (A6).
3. Make sure the cable supplied with the Wideband option is connected between the Wideband Output and Wideband Oscillator assemblies.
4. Uncoil the internal wideband output cable one turn from the Calibrator chassis and connect it to the coaxial connector on the Wideband Output Module. Make sure the cable is routed in such a way as to avoid shorting to ground when the board is installed in the chassis.
5. Install the Wideband Output and Wideband Oscillator Modules and lock the nylon ears.
6. Run the Wideband Gains Calibration procedure as described in Section 3.
7. Perform the Wideband Flatness Calibration procedure as described in Section 3. The Wideband option is now installed and ready for use.

Clearing Ghost Images from the Control Display 4-20.

After prolonged periods of displaying the same message on the Control Display, you may notice a non-uniform brightness of pixels across the display. This phenomenon can be cleared up by lighting up the whole display and leaving it on overnight (or at least several hours). Proceed as follows to burn in the Control Display:

1. Turn on the Calibrator and press the "Setup Menus" softkey.
2. Press the "Self Test & Diags" softkey.
3. Press the "5700 Self Diags" softkey.
4. Press the "Front Panel Tests" softkey.
5. Under the "Display" label, press the "Control" softkey.
6. Press the "All On" softkey. This causes all Control Display pixels to light. Press the RESET key or press PREV MENU six times to return to normal operation after an overnight or equivalent burn in period.

Replacing the Clock/Calendar Backup Battery 4-21.

To replace the lithium button-type battery on the CPU Assembly (A20), proceed as follows:

1. Make sure the power is off and the line power cord disconnected.

2. Follow the access procedures to remove the digital side cover.
3. Remove the CPU Assembly (A20).
4. Desolder and remove battery BT1.
5. Solder a replacement battery in place (refer to the parts list for replacement information if necessary.)
6. Replace the CPU Assembly. After replacing the battery, the setting of the time and date the elapsed time counter (read by the remote query ETIME? and set by ETIME) will need to be reprogrammed.

Using Remote Commands Reserved for Servicing 4-22.

This information documents remote commands not described in the 5700A/5720A Series II Operator Manual, Section 5. The commands described here are useful for servicing the instrument.

Using the ETIME Command 4-23.

The ETIME remote command is the companion to ETIME?, the elapsed time query, which is documented in the Operator Manual. The ETIME? query tells you how many minutes the Calibrator has been in the power on state since the instrument was built. If you replace the CPU Assembly (A20), the clock/calendar battery (BT1), or the clock/calendar IC (U33), you will lose the setting of ETIME. The ETIME command gives you a way to set this counter to where it was before servicing the instrument. (If possible, read the counter first using ETIME?.) The syntax for this remote command is as follows:

ETIME

Description:

Sets the elapsed time counter to any number of minutes from 0 to 2,147,483,647. The setting of this counter is read by the ETIME? query, described in the 5700A/5720A Series II Operator Manual. (Sequential command.)

Parameter:

1. SET_TO
2. Integer, number of minutes

Example:

ETIME SET_TO, 4628000

Using The Fatality? and Fatalclr Commands

The FATALITY? query recovers fault codes that were logged when a fatal problem occurred. These faults are logged into a separate fault queue. Once the faults are read from the queue, you can clear the queue by sending the FATALCLR command. The syntax for these remote commands are as follows:

FATALITY?

Description:

Returns the list of the fatal faults logged since the list was last cleared by the FATALCLR command. (Sequential command.)

Parameter:

None

Response:

(String) The list of faults, one per line in the following format:

<date> <time> <fault code> <fault description string> <EOL>

Example:

```
"8/30/88                              6:33:49 Fault
8/30/88                               6:34:05 Fault
8/30/88                               6:34:12 Fault
8/30/88                               6:34:13 Fault
8/30/88                               6:34:14 Fault
8/30/88                               6:34:15 Fault
8/30/88                               6:34:16 Fault
```

FATLCLR?

Description:

Clears the list of the fatal faults logged since the list was last cleared by the FATALCLR command. The list is read by the FATALITY? query. (Sequential command.)

Parameter:

None

Chapter 5
Troubleshooting

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Introduction 5-1.

Information in this section begins with guidance in using self-diagnostics fault codes to isolate a faulty module. The descriptive text helps to quickly locate the source of a fault. Further on, under Component Level Troubleshooting, techniques for isolating faulty components or circuits are described. The Component Level Troubleshooting is only for qualified service personnel who do not wish to replace a faulty module through the Fluke Module Exchange Program. (Refer to Section 1 for module exchange instructions.)

Warning

To avoid electric shock, disconnect all cables from the output and sense binding posts and do not touch binding post during self diagnostics.

Interpreting Diagnostic Fault Codes 5-2.

Run self diagnostics by pressing the "Setup Menus" then the "Self Test & Diags" softkey.

Note

Self test diagnostics of the analog circuitry are carried out with the 5700A/5720A Series II binding posts open circuited. (Cables and test equipment left connected to the binding posts have no effect.)

Test routines connect specific points to the SDL or RCL line and measuring for an expected voltage and tolerance. The SDL and RCL lines are routed to the adc circuit on the DAC assembly for measurement.

Fault code descriptions generally indicate the instrument's test configuration, point being measured, expected voltage, and probable assembly which is at fault. In some cases, an addition manual measurement may be required to determine the faulty assembly. These manual measurements are Noted with the related fault code description. In all cases it is assumed that the Motherboard assemblies are fully operational. Power Supply faults assume that other, non-power supply related assemblies are not loading down the Power Supply.

2700 A7: 8255 Control Word

The diagnostics software reads the control word of the 8255 IC on the Current/Hi Res assembly. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2701 A7: 8255 Port a Fault

The diagnostics software writes and reads data to port A of the 8255 IC on the Current/Hi Res assembly. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2702 A7: 8255 Port B Fault

The diagnostics software reads port B of the 8255 IC on the Current/Hi Res assembly. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2703 A7: 8255 Port C Fault

The diagnostics software reads port C of the 8255 IC on the Current/Hi Res assembly. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2704 Spare

This fault code is not used.

2705 A7: Oven Regulation Fault

The heater voltage of the current hybrid is measured by dividing OVEN TEMP down and connecting it to the SDL line where it is measured by the adc circuit on the DAC assembly to ensure the hybrid is warmed up and regulating. OVEN TEMP should be 0.7V ±10% ±0.2V. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2706 A7: Current Compliance Fault

The Current assembly is configured into each of its ranges in both the dc and ac mode. The output current is connected to the 1.2Ω load resistor. The compliance voltage is determined by measuring the output side of the shunt resistor via the Current/Compliance Voltage Monitor circuit. This fault occurs if the voltage is 10% over the expected. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2707 A7: Hardware Initialization Fault

This fault occurs if the diagnostics software was unable to properly set the Current assembly hardware for diagnostics testing. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2708 Spare

This fault code is not used.

2709 A7: Current Magnitude Fault

The Current assembly is configured into each of its ranges in both the dc and ac mode. The output current is connected to the 1.2Ω load resistor and the current is calculated by measuring the voltage drop across the shunt resistance. This fault occurs if the voltage is 10% over the expected. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2710 A7: Dummy Load Current Fault

The Current assembly is configured into each of its dc ranges. The output current is connected to the 1.2Ω load resistor and the resulting voltage on DUMMY LOAD is connected to the SDL line where it is measured by the adc circuit on the DAC assembly. This fault occurs if the current is over 10% ±5 mA of the output current. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2711 Assembly A7 Is Not Responding

At power up the instrument checks to see what assemblies are not installed. This test verifies that the Current assembly is not responding. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2712 A7: Hi-Res Clock Fault

The Hi-Res clock circuit is checked by connecting HI-RES CLOCK to the SDL line which is measured by the adc circuit on the DAC assembly for 2.5V ±200 mV. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2713 A7: Hi-Res Loop In 100Hz Range

The instrument is set for 2.0V at 100 Hz operation. The input voltage to the VCO circuit is resistively divided to create the control line HI-RES LOOP. HI-RES LOOP is connected to the SDL line where it is measured by the adc circuit on the the DAC assembly. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2714 A7: Hi-res Loop In 1kHz Range

The instrument is set for 2.0V at 900 Hz operation. The input voltage to the VCO circuit is resistively divided to create the control line HI-RES LOOP. HI-RES LOOP is connected to the SDL line where it is measured by the adc circuit on the the DAC assembly. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2715 A7: Hi-res Loop In 10kHz Range

The instrument is set for 2.0V at 11 kHz operation. The input voltage to the VCO circuit is resistively divided to create the control line HI-RES LOOP. HI-RES LOOP is connected to the SDL line where it is measured by the adc circuit on the the DAC assembly. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2716 A7: Hi-res Loop In 100kHz Range

The instrument is set for 2.0V at 70 kHz operation. The input voltage to the VCO circuit is resistively divided to create the control line HI-RES LOOP. HI-RES LOOP is connected to the SDL line where it is measured by the adc circuit on the the DAC assembly. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2717 A7: Hi-res Loop In 1MHz Range

The instrument is set for 2.0V at 121 kHz, 600 kHz, and 1.19 MHz operation. The input voltage to the VCO circuit is resistively divided to create the control line HI-RES LOOP. HI-RES LOOP is connected to the SDL line where it is measured by the adc circuit on the the DAC assembly at each frequency. This fault occurs if the VCO input voltage is not within 25% ±1.0V of the expected voltage. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2718 Fault In Setting Up AC For Diagnostics

This fault occurs if the diagnostics software was unable to properly set the Hi-Resolution Oscillator hardware for diagnostics testing. A failure indicates the Current/Hi Res assembly (A7) is probably at fault.

2719 A7: 8255 Was Reset

The control word of the 8255 on the Current/Hi Res assembly is determined to be incorrect. A failure indicates the Current/Hi Res assembly is probably at fault.

2800 A11: 8255 Control Word

The diagnostics software reads the control word of the 8255 IC on the DAC assembly. A failure indicates the DAC assembly (A11) is probably at fault.

2801 A11: 8255 Port a Wires

The diagnostics software writes and reads data to port A of the 8255 IC on the DAC assembly. A failure indicates the DAC assembly (A11) is probably at fault.

2802 A11: 8255 Port B Data Bus

The diagnostics software reads port B of the 8255 IC on the DAC assembly. A failure indicates the DAC assembly (A11) is probably at fault.

2803 A11: 8254 Status Words

The diagnostics software reads the status of the 82C54 IC on the DAC assembly. A failure indicates the DAC assembly (A11) is probably at fault.

2804 A11: DAC Heaters Not Regulated

The instrument is dormant and the heater voltages (REF HEATER and DCAMP HEATER) to the hybrid assemblies are measured to be 0.7V ±10% ±0.2V. A failure indicates the DAC assembly (A11) is probably at fault.

2805 5700 Not Warmed Up

If a heated hybrid assembly in the instrument is detected to not be in regulation the length of time since the last reset is checked. This fault occurs if the time is less than ten minutes since a reset.

2806 A11: ADC Amp Output Noise

The instrument is dormant. The ± inputs of the DAC adc amplifier circuit are connected to common and the adc then takes ten readings. This failure occurs if the difference between the lowest value and highest value of the ten readings is greater than 500 μV. A failure indicates the DAC assembly (A11) is probably at fault.

2807 A11: ADC Amp Output Offset

The instrument is dormant. The ±inputs of the DACs adc amplifier circuit are connected to common and the adc then takes ten readings. This failure occurs if the average of the ten readings is greater than 3 mV. A failure indicates the DAC assembly (A11) is probably at fault.

2808 A11: ADC Amp Gain Error

The DAC is set to 0.1V on the 11V range and connected to the +input of the DACs adc amplifier circuit and the -input is connected to common. The adc amplifier has a nominal gain of 11 resulting in 1.1V at the adc amplifier output. This gain is checked to be 11 ±5%. A failure indicates the DAC assembly (A11) is probably at fault.

2809 A11: DAC Monitoring Fault

The DAC is set to 1.0V and routed to the adc circuit via DAC HI DIAG. This 1V from the DAC is divided by R70 and R84 on the DAC before going to the adc circuit where it is measured. The DAC is then set to 10V and another reading is taken by the adc. The exact gain of the divider resistors can now be determined by the formula:

Gain = (10-1V) / (adc10-adc1)

A failure occurs if the detected gain is not within 10% of the nominal 22.13. A failure indicates the DAC assembly (A11) is probably at fault.

2810 A11: +11V DC Range Fault

The instrument is configured in the +11V dc range. The DAC is sequentially set to 0V, 1V, and 10V. The DAC output is measure at each setting to be within 7% ±10 mV via DAC HI DIAG by the adc circuit. A failure indicates the DAC assembly (A11) is probably at fault.

2811 A11: -11V DC Range Fault

The instrument is configured in the -11V dc range. The DAC is sequentially set to 0V, -1V, and -10V. The DAC output is measure at each setting to be within 7% ±10 mV via DAC HI DIAG by the adc circuit. A failure indicates the DAC assembly (A11) is probably at fault.

2812 A11: +22V DC Range Fault

The instrument is configured in the +22V dc range. The DAC is sequentially set to 0V, 2V, and 21.9V. The DAC output is measure at each setting to be within 7.2% ±10 mV via DAC HI DIAG by the adc circuit. A failure indicates the DAC assembly (A11) is probably at fault.

2813 A11: -22V DC Range Fault

The instrument is configured in the -22V dc range. The DAC is sequentially set to 0V, -2V, and -21.9V. The DAC output is measure at each setting to be within 7.2% ±10 mV via DAC HI DIAG by the adc circuit. A failure indicates the DAC assembly (A11) is probably at fault.

2814 A11: 6.5V Buffered Reference Fault

The DAC's 6.5V buffered reference (BRF6 and BSRF6) is connected to the -input of the adc circuit and the DAC output (DAC SENSE CAL) is connected to the +input. The 6.5V buffered reference is measure by adjusting the DAC until a null is achieved. This fault occurs if the 6.5V buffered reference is over 10% of the nominal. A failure indicates the DAC assembly (A11) is probably at fault.

2815 A11: 6.5V Reference Fault

The DAC's 6.5V reference (REF6) is connected to the -input of the adc circuit and the DAC output (DAC SENSE CAL) is connected to the +input. The 6.5V reference is measure by adjusting the DAC until a null is achieved. This fault occurs if the 6.5V reference is over 10% of the nominal. A failure indicates the DAC assembly (A11) is probably at fault.

2816 A11: 13V Buffered Reference Fault

The DAC's 13V buffered reference (BRF13 and BSRF13) is connected to the -input of the adc circuit and the DAC output (DAC SENSE CAL) is connected to the +input. The 13V buffered reference is measure by adjusting the DAC until a null is achieved. This fault occurs if the 13V buffered reference is over 10% of the nominal. A failure indicates the DAC assembly (A11) is probably at fault.

2817 A11: 13V Reference Fault

The DAC's 13V reference (REF13) is connected to the -input of the adc circuit and the DAC output (DAC SENSE CAL) is connected to the +input. The 13V reference is measure by adjusting the DAC until a null is achieved. This fault occurs if the 13V reference is over 10% of the nominal. A failure indicates the DAC assembly (A11) is probably at fault.

2818 Assembly A11 Missing

At power up the instrument checks to see what assemblies are not installed. This test verifies that the DAC assembly is not responding. A failure indicates the DAC assembly (A11) is probably at fault.

2819 A11: 8255 Was Reset

The control word of the 8255 on the DAC assembly is read. A failure indicates the DAC assembly (A11) is probably at fault.

2820 A11: Fine Adjust Channel Fault

The second channel of the DAC assembly is tested. The second channel is set to a count which gives 0V at the DAC output. The output is measured by the adc circuit. The second channel count is increased and the increase in the DAC output is verified. A failure indicates the DAC assembly (A11) is probably at fault.

2821 A8/A11: +11/22V DC Zero Estimate Fault

The DAC is in either the +11V or +22V range. Its output (DAC SENSE CAL) is connected to the +input of the adc circuit and the -input of the adc circuit is connected to RCOM. The zero is estimated by adjusting the DAC until a null is achieved. This fault occurs when the nulling process does not converge. A failure indicates the DAC assembly (A11) is probably at fault.

2822 A8/A11: -11/22V DC Zero Estimate Fault

The DAC is in either the -11V or -22V range. Its output (DAC SENSE CAL) is connected to the +input of the adc circuit and the -input is connected to RCOM. The zero is estimated by adjusting the DAC until a null is achieved. This fault occurs when the nulling process does not converge. A failure indicates the DAC (A11) assembly is probably at fault.

2823 A11: Couldn't Estimate +11V Or 22V Gain

One of the DAC's references is connected to the -input of the adc circuit and DAC output (DAC SENSE CAL) is connected to the +input. The gain is estimated by adjusting the DAC until a null is achieved. This fault occurs when the nulling process does not converge. A failure indicates the DAC (A11) assembly is probably at fault.

2824 A11: Couldn't Estimate 6.5 MHz Or 13 MHz Ref

One of the DAC's references is connected to the -input of the adc circuit and DAC output (DAC SENSE CAL) is connected to the +input. The reference is estimated by adjusting the DAC until a null is achieved. This fault occurs when the nulling process does not converge. A failure indicates the DAC assembly (A11) is probably at fault.

2825 A11: Couldn't Est 6.5V Or 13V Buf Ref

One of the DAC's buffered references is connected to the -input of the adc circuit and DAC output (DAC SENSE CAL) is connected to the +input. The buffered reference is estimated by adjusting the DAC until a null is achieved. This fault occurs when the nulling process does not converge. A failure indicates the DAC (A11) assembly is probably at fault.

2826 A11: A/D Overload Fault

The adc on the DAC assembly is tested by putting a positive overload then a negative overload into the adc input. The adc output is read and compared against an expected overload reading for both the positive and negative overload. If either of these tests fail the fault message is sent. A failure on either of these tests indicates that the DAC assembly (A11) is at fault.

3100 A14: 8255 Control Word

The diagnostics software read the control word of the 8255 IC on the High Voltage Control assembly. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3101 A14: 8255 Port a Fault

The diagnostics software writes and reads data to port A of the 8255 IC on the High Voltage Control assembly. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3102 A14: 8255 Port B Fault

The diagnostics software reads port B of the 8255 IC on the High Voltage Control assembly. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3103 A14: 8255 Port C Fault

The diagnostics software reads port C of the 8255 IC on the High Voltage Control assembly. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3104 A15: HV Oven Regulation Fault

The heater voltage of the High Voltage/High Current assembly HR7 hybrid is divided by 11 and is measured by the adc circuit. The heater voltage should be 0.7V ±10% ±0.2V. If it is out of tolerance, the High Voltage/High Current assembly (A15) is probably at fault.

3105 A15: HV I Oven Regulation Fault

The heater voltage of the High Voltage/High Current assembly H4 hybrid is routed to the High Voltage Control assembly via HV MUX0. The High Voltage Control connects HV MUX0 to the SDL which is routed to the DAC assembly where it is measured by the adc circuit to be 0.7V ±10% ±0.2V. A failure indicates the High Voltage/High Current assembly (A15) is probably at fault.

3106 A15: DC HV Amp Noise Fault

The High Voltage assemblies are configured in the dormant state with the exception that the DAC output, set to 0.0V, is connected to the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly. This circuit is configured as an amplifier with a gain of 100 whose output is connected to the RCL line. The RCL line is routed to the DAC assembly where it is measured by the adc circuit. The adc circuit takes ten readings and this failure occurs if the difference between the lowest value and highest value of the ten readings is over 0.001V. A failure indicates the High Voltage/High Current assembly (A15) is probably at fault.

3107 A15: DC HV Amp Offset Fault

The High Voltage assemblies are configured in the dormant state with the exception that the DAC output, set to 0.0V, is connected to the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly. This circuit is configured as an amplifier with a gain of 100 whose output is connected to the RCL line. The RCL line is routed to the DAC assembly where it is measured by the adc circuit. The adc circuit takes ten readings and this failure occurs if the average value is over 0.003V. A failure indicates the High Voltage/High Current assembly (A15) is probably at fault.

3108 A15: DC HV Amp Gain Fault

The High Voltage assemblies are configured in the dormant state with the exception that the DAC output, set to -0.001V, is connected to the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly. This circuit is configured as an amplifier with a gain of -100 resulting in 0.1V at the output which is connected to the RCL line. The RCL line is routed to the DAC assembly where it is measured by the adc circuit. The gain of this circuit is determined by this reading along with the previously checked offset. This failure occurs if the determined gain is over 6% of the nominal -100. A failure indicates the High Voltage/High Current assembly (A15) is probably at fault.

3109 A15: HV +DC Preamplifier Fault

The instrument is set to the dc 1100V range with the amplitude set to 220V, 600V, and 1100V. The output of the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly is measured for 0.55V ±0.2V. This voltage is divided to create HV MUX2 which is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3110 A15: HV +DC Series Pass & Current Fault

The instrument is set to the dc 1100V range with the amplitude set to 220V, 600V, and 1100V. HV MUX3 from the HV DC OUTPUT SERIES PASS & CURRENT LIMIT circuit on the High Voltage/High Current assembly is measured for -0.035V ±0.02V. HV MUX3 is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3111 A15: HV +DC High Voltage Output Fault

The instrument is set to the dc 1100V range with the amplitude set to 220V, 600V, and 1100V. This output voltage is divided to create MUX5 which is connected to the SDL line for measurement by the adc circuit on the DAC assembly. This failure occurs if the expected output voltage is not within 12% of the nominal.

3112 A15: HV +DC Ref/error Amplitude Fault

The instrument is set to the dc 1100V range with the amplitude set to 220V, 600V, and 1100V. The control signal AMPLITUDE from the Magnitude Control circuitry of the High Voltage Control assembly is measured. The nominal gain from AMPLITUDE to HV OUT is 135. This gain is checked by measuring AMPLITUDE to be 0.0074 of the nominal output ±25%. AMPLITUDE is divided to create MUX7 which is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3113 A15: HV -DC Preamplifier Fault

The instrument is set to the dc 1100V range with the amplitude set to -220V, -600V, and -1100V. The output of the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly is measured for 2.3V ±0.2V. This voltage is divided to create HV MUX2 which is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3114 A15: HV -DC Series Pass & Current Fault

The instrument is set to the dc 1100V range with the amplitude set to -220V, -600V, and -1100V. HV MUX3 from the HV DC OUTPUT SERIES PASS & CURRENT LIMIT circuit on the High Voltage/High Current assembly is measured for -0.035V ±0.02V. HV MUX3 is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3115 A15: HV -DC High Voltage Output Fault

The instrument is set to the dc 1100V range with the amplitude set to -220V, -600V, and -1100V. This output voltage is divided to create MUX5 which is connected to the SDL line for measurement by the adc circuit on the DAC assembly. This failure occurs if the expected output voltage is not within 12% of the nominal.

3116 A15: HV -DC Reference/error Amp Fault

The instrument is set to the dc 1100V range with the amplitude set to -220V, -600V, and -1100V. The control signal AMPLITUDE from the Magnitude Control circuitry of the High Voltage Control assembly is measured. The nominal gain from AMPLITUDE to HV OUT is 135. This gain is checked by measuring AMPLITUDE to be 0.0074 of the nominal output ±25%. AMPLITUDE is divided to create MUX7 which is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3117 A14/A15: HV +DC Current Error Amp Fault

The Calibrator is set to the dc +2.2A current range with the amplitude set to +0.22A, +0.6A, and +1.2A. The control signal AMPLITUDE from the magnitude control circuitry of the High Voltage Control assembly is measured to be within 25% of the expected value. AMPLITUDE is divided to create MUX7 which is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3118 A14/A15: HV -DC Current Error Amp Fault

The Calibrator is set to the dc -2.2A current range with the amplitude set to -1.2A. The control signal AMPLITUDE from the magnitude control circuitry of the High Voltage Control assembly is measured to be within 25% of the expected value. AMPLITUDE is divided to create MUX7 which is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3119 A14/A15: HV +DC Current Abs. Value

The instrument is configured to the +DC 2.2A range and set for an output of 0.22A, 0.60A, and 1.2A. The output current from the High Voltage/High Current assembly is routed to the Current assembly where it is connected to the 1.2Ω load resistor. The Current control signal G OUT from the High Voltage/High Current assembly is routed to the Absolute Value Circuit on the High Voltage Control. The output from the Absolute Value circuit should be = 2.17 * I, ±25%, where "I" is the output current. This voltage is divided creating MUX6 which is connected to the SDL line where it is measured by the adc circuit on the DAC assembly.

3120 A14/A15: HV -DC Current Abs. Value

The instrument is configured to the -DC 2.2A range and set for an output of -1.2A. The output current from the High Voltage/High Current assembly is routed to the Current assembly where it is connected to the 1.2Ω load resistor. The Current control signal G OUT from the High Voltage/High Current assembly is routed to the Absolute Value Circuit on the High Voltage Control. The output from the Absolute Value circuit is a positive voltage which should be = 2.17 * I, ±25%, where "I" is the output current. This voltage is divided creating MUX6 which is connected to the SDL line where it is measured by the adc circuit on the DAC assembly.

3121 Spare

This fault code is not used.

3122 A14/A15: HV AC 1kHz, Preamp (Lo)

The instrument is configured to the ac 1100V range with on amplitude of 220V at 1 kHz. The output of the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly is measured for 0.0V ±0.2V. This voltage is divided to create HV MUX2 which is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3123 A14/A15: HV AC 1kHz, Preamp (Mid)

The instrument is configured to the ac 1100V range with on amplitude of 600V at 1 kHz. The output of the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly is measured for 0.0V ±0.2V. This voltage is divided to create HV MUX2 which is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3124 A14/A15: HV AC 1kHz, Preamp (Hi)

The instrument is configured to the ac 1100V range with on amplitude of 1100V at 1 kHz. The output of the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly is measured for 0.0V ±0.2V. This voltage is divided to create HV MUX2 which is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3125 A14/A15: HV AC 100Hz, Preamp (Lo)

The instrument is configured to the ac 1100V range with on amplitude of 220V at 50 Hz. The output of the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly is measured for 0.0V ±0.2V. This voltage is divided to create HV MUX2 which is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3126 A14/A15: HV AC 100Hz, Preamp Fault

The instrument is configured to the ac 1100V range with on amplitude of 600V at 50 Hz. The output of the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly is measured for 0.0V ±0.2V. This voltage is divided to create HV MUX2 which is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3127 A14/A15: HV AC 100Hz, Preamp (Hi)

The instrument is configured to the ac 1100V range with on amplitude of 1100V at 50 Hz. The output of the DC HV AMPLIFIER/AC SENSE BUFFER circuit of the High Voltage/High Current assembly is measured for 0.0V ±0.2V. This voltage is divided to create HV MUX2 which is routed to Diagnostic circuit on the High Voltage Control assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly.

3128 A14/A15: HV AC 1kHz, Output (Lo)

The instrument is configured to the ac 1100V range with on amplitude of 220V at 1 kHz. The high voltage output is divided and converted to a dc voltage by the OUTPUT PEAK MEASURE circuit to create MUX5. This dc voltage is equal to the positive peaks of the ac amplitude. MUX5 is connected to the SDL line for measurement by the adc circuit on the DAC assembly. The high voltage output is measured for 220V ±12%. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3129 A14/A15: HV AC 1kHz, Output (Mid)

The instrument is configured to the ac 1100V range with on amplitude of 600V at 1 kHz. The high voltage output is divided and converted to a dc voltage by the OUTPUT PEAK MEASURE circuit to create MUX5. This dc voltage is equal to the positive peaks of the ac amplitude. MUX5 is connected to the SDL line for measurement by the adc circuit on the DAC assembly. The high voltage output is measured for 600V ±12%. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3130 A14/A15: HV AC 1kHz, Output (Hi)

The instrument is configured to the ac 1100V range with on amplitude of 1100V at 1 kHz. The high voltage output is divided and converted to a dc voltage by the OUTPUT PEAK MEASURE circuit to create MUX5. This dc voltage is equal to the positive peaks of the ac amplitude. MUX5 is connected to the SDL line for measurement by the adc circuit on the DAC assembly. The high voltage output is measured for 1100V ±12%. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3131 A14/A15: HV AC 100Hz, Output (Lo)

The instrument is configured to the ac 1100V range with on amplitude of 220V at 50 Hz. The high voltage output is divided and converted to a dc voltage by the OUTPUT PEAK MEASURE circuit to create MUX5. This dc voltage is equal to the positive peaks of the ac amplitude. MUX5 is connected to the SDL line for measurement by the adc circuit on the DAC assembly. The high voltage output is measured for 220V ±12%. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3132 A14/A15: HV AC 100Hz, Output (Mid)

The instrument is configured to the ac 1100V range with on amplitude of 600V at 50 Hz. The high voltage output is divided and converted to a dc voltage by the OUTPUT PEAK MEASURE circuit to create MUX5. This dc voltage is equal to the positive peaks of the ac amplitude. MUX5 is connected to the SDL line for measurement by the adc circuit on the DAC assembly. The high voltage output is measured for 600V ±12%. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3133 A14/A15: HV AC 100Hz, Output (Hi)

The instrument is configured to the ac 1100V range with on amplitude of 1100V at 50 Hz. The high voltage output is divided and converted to a dc voltage by the OUTPUT PEAK MEASURE circuit to create MUX5. This dc voltage is equal to the positive peaks of the ac amplitude. MUX5 is connected to the SDL line for measurement by the adc circuit on the DAC assembly. The high voltage output is measured for 1100V ±12%. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3134 Spare

This fault code is not used.

3135 Assembly A14 Not Responding

At power up the instrument checks to see what assemblies are not installed. This test verifies that the High Voltage Control assembly is not responding. A failure indicates the High Voltage Control assembly is probably at fault.

3136 A14: 8255 Was Reset

The control word for the 8255 on the High Voltage Control assembly is read. A failure indicates the High Voltage Control assembly (A14) is probably at fault.

3137 A14/A15/A16: 2.2A AC Range Mag. Fault

The instrument is configured to the ac 2.2A range and set to 0.22A at 1 kHz, 0.6A at 1 kHz, 1.1A at 1 kHz, 0.6A at 40 Hz, and 1.1A at 50 Hz. The output current from the High Voltage/High Current assembly is routed to the Current assembly where it is connected to the 1.2Ω load resistor. The input current from the Current assembly is is measured at each setting by measuring the voltage drop across the 22 mA range shunt resistor on the Current assembly. This voltage drop is measured to be within 10% ±20 µV of the nominal. A failure indicates the High Voltage/High Current assembly (A15) is probably at fault.

3138 A14/A15/A16: 2.2A AC Range Compliance

The instrument is configured to the ac 2.2A range and set to 0.22A at 1 kHz, 0.6A at 1 kHz, 1.1A at 1 kHz, 0.6A at 40 Hz, and 1.1A at 50 Hz. The output current from the High Voltage/High Current assembly is routed to the Current assembly where it is connected to the 1.2Ω load resistor. The compliance voltage is determined by measuring the output side of the 22 mA range shunt resistor on the Current assembly. This is done via the Current Compliance Monitor circuit on the Current assembly and is checked to be less than 10V. A failure indicates the High Voltage/High Current assembly is probably at fault.

3139 A14/A15/A16: 2.2A AC Range Amplitude

The instrument is configured to the ac 2.2A range and set for an output current of 0.22A at 1 kHz, 0.6A at 1 kHz, 1.1A at 1 kHz, 0.6A at 40 Hz, and 1.1A at 50 Hz. The output current from the High Voltage/High Current assembly is routed to the Current assembly where it is connected to the 1.2Ω load resistor. The Current control signal G OUT from the High Voltage/High Current assembly is routed to the Magnitude Control circuit of the High Voltage Control assembly. The control signal AMPLITUDE is measured to be = I * 4.23 + 4.447, ±20%. This voltage is divided creating MUX7 which is connected to the SDL line where it is measured by the adc circuit on the DAC assembly.

3140 A14/A15/A16: 2.2A AC Range Abs. Value

The instrument is configured to the ac 2.2A range and set for an output current of 0.22A at 1 kHz, 0.6A at 1 kHz, 1.1A at 1 kHz, 0.6A at 40 Hz, and 1.1A at 50 Hz. The output current from the High Voltage/High Current assembly is routed to the Current assembly where it is connected to the 1.2Ω load resistor. The Current control signal G OUT from the High Voltage/High Current assembly is routed to the Absolute Value Circuit on the High Voltage Control. The output from the Absolute Value circuit is a positive voltage which should be = 3.07 * I, ±10%, where "I" is the output current. This voltage is divided creating MUX6 which is connected to the SDL line where it is measured by the adc circuit on the DAC assembly.

3141 A14/A15/A16: 2.2A DC Range Dummy Load

The instrument is configured to the dc 2.2A range. The output current from the High Voltage/High Current assembly is routed to the Current assembly where it is connected to the 1.2Ω load resistor. The resulting voltage across this load resistor is measured by connected DUMMY LOAD on the Current assembly to the SDL line where it is measured by the adc circuit on the DAC assembly. This fault occurs if the determined current is over 10% ±5 mA of the nominal. A failure indicates the High Voltage/High Current assembly (A15) is probably at fault.

3142 A14/A15/A16: 2.2A DC Range Compliance

The instrument is configured to the dc 2.2A range. The output current from the High Voltage/High Current assembly is routed to the Current assembly where it is connected to the 1.2Ω load resistor. The compliance voltage is determined by measuring the output side of the 22 mA range shunt resistor on the Current assembly. This is done via the Current Compliance Monitor circuit on the Current assembly and is checked to be less than 10V. A failure indicates the High Voltage/High Current assembly is probably at fault.

3143 A14/A15/A16: 2.2A DC Range Magnitude

The instrument is configured to the dc 2.2A range. The output current from the High Voltage/High Current assembly is routed to the Current assembly where it is connected to the 1.2Ω load resistor. The output current is calculated by measuring the voltage drop across the 22 mA range shunt resistor on the Current assembly. This fault occurs if the determined current is over 10% of the nominal. A failure indicates the High Voltage/High Current assembly (A15) is probably at fault.

3300 A9: 8255 Control Word

The diagnostics software reads the control word of the 8255 IC on the Ohms Cal assembly (A9). A failure indicates the Ohms Cal assembly (A9) is probably at fault.

3301 A9: 8255 Port a Fault

The diagnostics software writes and reads data to port A of the 8255 IC on the Ohms Cal assembly (A9). A failure indicates the Ohms Cal assembly (A9) is probably at fault.

3302 A9: 8255 Port B Fault

The diagnostics software reads port B of the 8255 IC on the Ohms Cal assembly (A9) during the instruments dormant state. A failure indicates the Ohms Cal assembly (A9) is probably at fault.

3303 A9: 8255 Port C Fault

The diagnostics software reads port C of the 8255 IC on the Ohms Cal assembly (A9) during the instruments dormant state. A failure indicates the Ohms Cal assembly (A9) is probably at fault.

3304 A9: 10V Source Fault

The 2/5/10V SOURCE circuit on the Ohms Cal assembly (A9) is set for 10V and routed to the adc circuit on the DAC assembly, via the SDL line, where it is measured for 10V ±7%. This 10V can be verified with a DMM, hi to TP13 and low to TP12. If the measured voltage is out of tolerance, the 2/5/10V SOURCE circuit on the Ohms Cal assembly (A9) is faulty. If the measured voltage is within tolerance, the diagnostic circuit on the Ohms Cal assembly (A9) is probably at fault.

Note

If extender cards are available, verify that 10V SENSE LOis tied to SCOM. This connection is done with relays onboth the Ohms assemblies.

3305 A9: 5V Source Fault

The 2/5/10V SOURCE circuit on the Ohms Cal assembly (A9) is set for 5V and routed to the adc circuit on the DAC assembly, via the SDL line, where it is measured for 5V ±7%. A failure indicates the 2/5/10V SOURCE circuit on the Ohms Cal assembly (A9) is probably at fault.

Note

If extender cards are available verify that 10V SENSE LOis tied to SCOM. This connection is done with relays onboth the Ohms assemblies.

3306 A9: 2V Source Fault

The 2/5/10V SOURCE circuit on the Ohms Cal assembly (A9) is set for 2V and routed to the adc circuit on the DAC assembly, via the SDL line, where it is measured for 2V ±7%. A failure indicates the 2/5/10V SOURCE circuit on the Ohms Cal assembly (A9) is probably at fault.

Note

If extender cards are available verify that 10V SENSE LOis tied to SCOM. This connection is done with relays onboth the Ohms assemblies.

3307 Spare

This fault code is not used.

3308 A9: Diff Amp Offset Fault

The offset of the Differential Amplifier circuit on the Ohms Cal assembly (A9) is checked. The DAC output is set to 0V and connected to both the ±inputs of the Differential Amplifier circuit. The output is routed to the adc circuit on the DAC assembly via the RCL line. Ten reading are taken and this fault occurs of the difference between the lowest and highest value if over 1 mV or if the absolute value is over

10 mV. A failure indicates the Differential Amplifier circuit on the Ohms Cal assembly (A9) is probably at fault.

3309 A9: Diff Amp Gain Fault

The gain (nominal gain of 75) Differential Amplifier circuits on the Ohms Cal assembly (A) is checked. The DAC output is set to 86.7 mV and connected to the -input of the Diff Amp circuit with the +input connected to RCOM. The output of the Diff Amp circuit is routed to the adc circuit on the DAC assembly, via the RCL line, where it is compared to the 6.5V reference. This fault occurs if the determined gain is over 6% from the nominal 75. A failure indicates the Differential Amplifier circuit on the Ohms Cal assembly (A9) is probably at fault.

3310 A9: Diff Amp Noise Fault

The noise of the differential amplifier circuit on the Ohms Cal assembly (A9) is checked. The DAC output is set to 0V and connected to both the ±inputs of the differential amplifier circuit. The output is routed to the adc circuit on the DAC assembly via the RCL line. Ten readings are taken and this fault occurs if the difference between the lowest and highest value if over 1 mV. A failure indicates the differential amplifier circuit on the Ohms Cal assembly (A9) is probably at fault.

3311 A9/A10: Ohms 10:1 Divider Fault

The 2/5/10V SOURCE circuit is set for 10V and connected across the 100 kΩ resistance in Z5 on the Ohms Cal assembly (A9). The resulting 1V across the 10 kΩ portion is measure for 1V ±3% ±15 mV. A failure indicates the Ohms Cal assembly (A9) is probably at fault.

3312 A9/A10: Ohms 1:1 Divider Fault

The 2/5/10V SOURCE circuit is set for 10V and connected across the 100 kΩ resistance in Z5 on the Ohms Cal assembly (A9). This arrangement is measured for 10V ±3% ±15 mV. A failure indicates the Ohms Cal assembly (A9) is probably at fault.

3313 A9/A10: 10 Kilohm Diagnostic Fault

The 2/5/10V SOURCE circuit is set for 10V and connected across the 20 kΩ resistance made from the 10 kΩ in Z5 on the Ohms Cal assembly, (A9) and the 10 kΩ string on the Ohms Main assembly (A10) connected in series. The resulting 5V across the 10 kΩ string on the Ohms Main assembly is measured for 5V ±3% ±15 mV. Measure the 5V across the 10 kΩ string by connecting a DMM hi to TP2 and low to TP1 on the Ohms Cal assembly (A9). If this voltage is greater than 5V the Ohms Main assembly (A10) is probably at fault. If the voltage is less than or equal to 5V the Ohms Cal assembly (A9) is probably at fault.

3314 A9/A10: 19 Kilohm Cal Diag Fault

The 2/5/10V SOURCE circuit is set for 10V and connected across the 29 kΩ resistance made from the 10 kΩ in Z5 on the Ohms Cal assembly, (A9) and the 19 kΩ string on the Ohms Main assembly (A10) connected in series. The resulting 6.55V across the 19kΩ string on the Ohms Main assembly is measured for 6.55V ±3% ±15 mV. A failure indicates the Ohms Main assembly (A10) is probably at fault.

3315 A9/A10: 10 Ohm Cal Diag Fault

The 2/5/10V SOURCE circuit is set for 2V and connected across the 100Ω string on the Ohms Main assembly. The resulting 0.2 V across the 10Ω portion is connected to the -input of the Differential Amplifier on the Ohms Cal assembly. The output of the DAC assembly is set to 2V and connected across the 100 kΩ resistance in Z5 on the Ohms Cal assembly. The resulting 0.2V across the 10 kΩ portion of Z5 is connected to the +input of the Differential Amplifier. The output of the Differential Amplifier is routed to the adc circuit on the DAC assembly, via the RCL line, and measured for 0V ±3% ±15 mV. Verify that the divided DAC voltage of 0.2V ±5% is at the +input of the Diff Amp by connecting DMM hi to TP20 and low to TP10 of the Ohms Cal assembly. If this measured voltage is out of tolerance, the Ohms Cal assembly (A9) is probably at fault.

3316 A9/A10: 19 Ohm Cal Diag Fault

The 2/5/10V SOURCE circuit is set for 2V and connected across the 190Ω string on the Ohms Main assembly. The resulting 0.2V across the 10Ω portion is connected to the -input of the Differential Amplifier on the Ohms Cal assembly. The output of the DAC assembly is set to 2V and connected across the 100 kΩ resistance in Z5 on the Ohms Cal assembly. The resulting 0.2V across the 10 kΩ portion of Z5 is connected to the +input of the Differential Amplifier. The output of the Differential Amplifier is routed to the adc circuit on the DAC assembly, via the RCL line, and measured for 0V ±3% ±15 mV. A failure indicates the calibration of the 19Ω resistance on the Ohms Main assembly (A10) is probably at fault.

3317 A9/A10: 100 Kilohm Ratio Fault

The 2/5/10V SOURCE circuit on the Ohms Cal assembly is set to 10V which is routed to the Ohms Main assembly and connected to the 100 kΩ string. The resulting 1V across the 10 kΩ portion is measured for 1V ±3% ±15 mV. A failure indicated the Ohms Main assembly (A10) is probably at fault.

3318 A9/A10: 190 Kilohm Ratio Fault

The 2/5/10V SOURCE circuit on the Ohms Cal assembly is set to 10V which is routed to the Ohms Main assembly and connected to the 190 kΩ string. The resulting 1V across the 19 kΩ portion is measured for 1V ±3% ±15 mV. A failure indicated the Ohms Main assembly (A10) is probably at fault.

3319 A9/A10: 1M Ohm Ratio Fault

The 2/5/10V SOURCE circuit on the Ohms Cal assembly is set to 10V which is routed to the Ohms Main assembly and connected to the 1 MΩ string. The resulting 1V across the 100 kΩ portion is measured for 1V ±3% ±15 mV. Measure the 1 volt across the 100 kΩ string by connecting a DMM hi to TP14 and low to TP2 of the Ohms Cal assembly (A9). If the voltage is out of tolerance, the Ohms Main assembly (A10) is probably at fault. If the voltage is within tolerance, the Ohms Cal assembly (A9) if probably at fault.

3320 A9/A10: 1.9M Ohm Ratio Fault

The 2/5/10V SOURCE circuit on the Ohms Cal assembly is set to 10V which is routed to the Ohms Main assembly and connected to the 1.9 MΩ string. The resulting 1V across the 190 kΩ portion is measured for 1V ±3% ±15 mV. A failure indicated the Ohms Main assembly (A10) is probably at fault.

3321 A9/A10: 10M Ohm Ratio Fault

The 2/5/10V SOURCE circuit on the Ohms Cal assembly is set to 10V which is routed to the Ohms Main assembly and connected to the 10 MΩ string. The resulting 1V across the 1 MΩ portion is measured for 1V ±3% ±15 mV. A failure indicated the Ohms Main assembly (A10) is probably at fault.

3322 A9/A10: 19M Ohm Ratio 1

The 2/5/10V SOURCE circuit on the Ohms Cal assembly is set to 10V which is routed to the Ohms Main assembly and connected to the 19 MΩ string. The resulting 1V across the 1.9 MΩ portion is measured for 1V ±3% ±15 mV. A failure indicated the Ohms Main assembly (A10) is probably at fault.

3323 A9/A10: 19M Ohm Ratio 2

The 2/5/10V SOURCE circuit on the Ohms Cal assembly is set to 10V which is routed to the Ohms Main assembly and connected to the 19 MΩ string. This 10V across the 19 MΩ portion is measured for 10V ±3% ±15 mV. A failure indicated the Ohms Main assembly (A10) is probably at fault.

3324 A9/A10: 100M Ohm Ratio Fault

The 2/5/10V SOURCE circuit on the Ohms Cal assembly is set to 10V which is routed to the Ohms Main assembly and connected to the 10 MΩ string. The resulting 1V across the 1 MΩ portion is measured for 1V ±3% ±15 mV. A failure indicated the Ohms Main assembly (A10) is probably at fault.

3325 A9/A10: 10 Kilohm Check Fault

The Current assembly (A7) outputs 0.13 mA which is routed to the Ohms Main assembly (A10), via INT OUT HI, where it is connected to the 10 kΩ string. The voltage drop across the 10 kΩ string is measured for 1.3V ±3% ±15 mV. Measure this voltage drop by connecting the DMM hi to TP5 and the low to TP6 of the Ohms Cal assembly (A9). If the voltage is out of tolerance, the Ohms Main assembly is probably at fault. If the voltage is within tolerance, the Ohms Cal assembly is probably at fault.

3326 A9/A10: 19 Kilohm Check Fault

The Current assembly (A7) outputs 0.13 mA which is routed to the Ohms Main assembly (A10), via INT OUT HI, where it is connected to the 19 kΩ string. The voltage drop across the 19 kΩ string is measured for 2.47V ±3% ±15 mV. A failure indicates the Ohms Main assembly is probably at fault.

3327 A9/A10: 1 Kilohm Check Fault

The Current assembly (A7) outputs 1.3 mA which is routed to the Ohms Main assembly (A10), via INT OUT HI, where it is connected to the 1 kΩ string. The voltage drop across the 1 kΩ string is measured for 1.3V ±3% ±15 mV. A failure indicates the Ohms Main assembly is probably at fault.

3328 A9/A10: 1.9 Kilohm Check Fault

The Current assembly (A7) outputs 1.3 mA which is routed to the Ohms Main assembly (A10), via INT OUT HI, where it is connected to the 1.9 kΩ string. The voltage drop across the 1.9 kΩ string is measured for 2.47V ±3% ±15 mV. A failure indicates the Ohms Main assembly (A10) is probably at fault.

3329 A9/A10: 100 Ohm Check Fault

The Current assembly (A7) outputs 13 mA which is routed to the Ohms Main assembly (A10), via INT OUT HI, where it is connected to the 100Ω string. The voltage drop across the 100Ω string is measured for 1.3V ±3% ±15 mV. A failure indicates the Ohms Main assembly is probably at fault.

3330 A9/A10: 190 Ohm Check Fault

The Current assembly (A7) outputs 13 mA which is routed to the Ohms Main assembly (A10), via INT OUT HI, where it is connected to the 190Ω string. The voltage drop across the 190Ω string is measured for 2.47V ±3% ±15mV. A failure indicates the Ohms Main assembly (A10) is probably at fault.

3331 A9/A10: 10 Ohm Check Fault

The Current assembly (A7) outputs 130 mA which is routed to the Ohms Main assembly (A10), via INT OUT HI, where it is connected to the 10 Ohm resistance. The voltage drop across the 10Ω resistance is measured for 1.3V ±3% ±15 mV. A failure indicates the Ohms Main assembly is probably at fault.

3332 A9/A10: 19 Ohm Check Fault

The Current assembly (A7) outputs 130 mA which is routed to the Ohms Main assembly (A10), via INT OUT HI, where it is connected to the 19Ω resistance. The voltage drop across the 19Ω string is measured for 2.47V ±3% ±15 mV. A failure indicates the Ohms Main assembly is probably at fault.

3333 A9/A10: 1 Ohm Check Fault

The Current assembly (A7) outputs 130 mA which is routed through the Ohms Main assembly (A10), via INT OUT HI, to the Ohms Cal assembly (A9) where it is connected to the 1Ω resistance. The voltage drop across the 1Ω resistance is measured for 0.13V ±3% ±15 mV. A failure indicates the Ohms Cal assembly is probably at fault.

3334 A9/A10: 1.9 Ohm Check Fault

The Current assembly (A7) outputs 13 mA which is routed through the Ohms Main assembly (A10), via INT OUT HI, to the Ohms Cal assembly (A9) where it is connected to the 1.9Ω resistance. The voltage drop across the 1.9Ω resistance is measured for 24.7 mV ±3% ±15 mV. A failure indicates the Ohms Cal assembly is probably at fault.

3335 A9/A10: Ohms Short Check Fault

The Current assembly (A7) outputs 130 mA which is routed through the Ohms Main assembly (A10), via INT OUT HI, to the Ohms Cal assembly (A9) where it is connected to the short. The voltage drop across the short is measured for 0V ±3% ±15 mV. A failure indicates the Ohms Cal assembly is probably at fault.

3336 A9/A10: 2 Wire Compensation Fault

The two-wire compensation circuit is tested at its limits. The tests check to see if the circuit can compensate for lead drops for the following currents and loads:

- 10 mA into 10Ω
- -10 mA into 10Ω
- 10 µA into 10 kΩ
- 5.6 µA into 19 kΩ

The Current assembly (A7) generates the desired current which is routed through the Ohms Main assembly (A10), via INT OUT HI, to the Ohms Cal assembly (A9) where it is connected to ACOM. The current into ACOM causes the 2 Wire Lead Drop Compensation circuit to generate a voltage which is used in creating an equal current in the opposite polarity for the current in ACOM. The voltage is measured on the DAC assembly via the SDL line. The voltage expected from the compensation circuit is V = I * -1000V/A. Failure of any of the tests indicates that the 2 Wire Lead Drop Compensation circuit on the Ohms Cal assembly (A9) is probably at fault.

3337 A9/A10: Ohms Correction Factor Fault

The 13 volt reference on the DAC assembly is checked by the adc circuit on the DAC assembly. A failure indicates the DAC assembly (A11) is probably at fault.

3338 Assembly A9 Not Responding

At power up the instrument checks to see what assemblies are not installed. This test verifies that the Ohms Cal assembly is not responding. A failure indicates the Ohms Cal assembly (A9) is probably at fault.

3339 A9: 8255 Was Reset

The control word of the 8255 on the Ohms Cal assembly is read. A failure indicates the Ohms Cal assembly (A9) is probably at fault.

3340 A9/A10: 100 Ohm Cal Diag Fault

The 2/5/10V SOURCE circuit is set for 2V and connected across the 1 kΩ string on the Ohms Main assembly. The resulting 0.2V across the 100Ω portion is connected to the - input of the differential amplifier on the Ohms Cal assembly. The output of the DAC assembly is set to 2V and connected across the 100 kΩ resistance in Z5 on the Ohms Cal assembly. The resulting 0.2V across the 10 kΩ portion of Z5 is connected to the +input of the differential amplifier. The output of the differential amplifier is routed to the adc circuit on the DAC assembly, via the RCL line, and measured for 0V ±3% ±15 mV. A failure indicates the calibration of the 100Ω resistance on the Ohms Main assembly (A10) is probably at fault.

3341 A9/A10: 190 Ohm Cal Diag Fault

The 2/5/10V SOURCE circuit is set for 2V and connected across the 1.9 kΩ string on the Ohms Main assembly. The resulting 0.2V across the 190Ω portion is connected to the -input of the Differential Amplifier on the Ohms Cal assembly. The output of the DAC assembly is set to 2V and connected across the 100 kΩ resistance in Z5 on the Ohms Cal assembly. The resulting 0.2V across the 10 kΩ portion of Z5 is connected to the +input of the differential amplifier. The output of the differential amplifier is routed to the adc circuit on the DAC assembly, via the RCL line, and measured for 0V ±3% ±15 mV. A failure indicates the calibration of the 190Ω resistance on the Ohms Main assembly (A10) is probably at fault.

3400 A12: 8255 Control Word

The diagnostics software reads the control word of the 8255 IC on the Oscillator Control assembly. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3401 A12: 8255 Port A

The diagnostics software writes and reads data to port A of the 8255 IC on the Oscillator Control assembly. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3402 A12: 8255 Port B

The diagnostics software reads port B of the 8255 IC on the Oscillator Control assembly during the instruments dormant state. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3403 A12: 8255 Port C

The diagnostics software reads port C of the 8255 IC on the Oscillator Control assembly during the instruments dormant state. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3404 A13: 8255 Control Word

The diagnostics software reads the control word of the 8255 IC on the Oscillator Output assembly. A failure indicates the Oscillator Output assembly (A13) is probably at fault.

3405 A13: 8255 Port A

The diagnostics software writes and reads data to port A of the 8255 IC on the Oscillator Output assembly. A failure indicates the Oscillator Output assembly (A13) is probably at fault.

3406 A13: 8255 Port B

The diagnostics software reads port B of the 8255 IC on the Oscillator Output assembly during the instruments dormant state. A failure indicates the Oscillator Output assembly (A13) is probably at fault.

3407 A13: 8255 Port C

The diagnostics software reads port C of the 8255 IC on the Oscillator Output assembly during the instruments dormant state. A failure indicates the Oscillator Output assembly (A13) is probably at fault.

3408 A13: Fixed Ampl. Osc Fault

The instrument is set for 1V ac at 100 Hz, 1 kHz, 10 kHz, 100 kHz, and 1 MHz. The signal line INTEGRATOR OUT on the Oscillator Output assembly is measured via the SDL line. Each frequency range is tested at the fixed 1V amplitude. INTEGRATOR OUT is measured to be 0V ±1V at the lower three frequency ranges, ±2V at the 100 kHz range, and ±5V at the 1 MHz range. A failure indicates the Oscillator Output assembly (A13) is probably at fault.

3409 A13: Phase Lock Loop Fault

The instrument is set for 1V ac at 100 Hz, 1 kHz, 10 kHz, 100 kHz, and 1 MHz. The signal line LOOP FILTER OUT on the Oscillator Output assembly is measured via the SDL line. Each frequency range is tested at the fixed 1V amplitude. LOOP FILTER OUT is measured to be 0V ±5V. A failure indicates the Oscillator Output assembly (A13) is probably at fault.

3410 A12/A13: 22V Amp Bias Adj Error

The instrument is set for 1V and 10V at 1 kHz operation. Signal line AMP1 on the Oscillator Output assembly is measured via the SDL line. A failure indicates that AMP1 was measured to be greater than 500 mV but less than 2V. A failure indicates the Oscillator Output assembly (A13) is probably at fault. Check the zero adjustment of potentiometer R30 on the OSC SMD AMP assembly.

3411 A12/A13: 22V Amp Nonfunctional

The instrument is set for 1V and 10V at 1 kHz operation. Signal line AMP1 on the Oscillator Output assembly is measured via the SDL line. A failure indicates that AMP1 was measured to be greater than 2V. A failure indicates the Oscillator Output assembly (A13) is probably at fault.

3412 A12 To A13 Interface Fault

The instrument is set for 1V 1 kHz operation. Signal VREF on the Oscillator Control assembly (A12) is measured via the SDL line to be 3.16V ±100 mV. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3413 A12/A13: 14 Bit DAC Nonfunctional

The instrument is set for 1V 1 kHz operation. Signal 14 BIT DAC OUT on the Oscillator Control assembly is measured via the SDL line. The 15 bit DAC circuit on the Oscillator Control assembly is set for outputs of 0V, -1.58V, and -3.16V, and is measured to be within ± 100 mV. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3414 A12/A13: Nonlinear Control Loop 2vrng

The instrument is set for 1V 1 kHz operation. Signal ERROR INT. OUT on the Oscillator Control assembly is measured via the SDL line to be 0V ±5.0V. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3415 A12/A13: Nonlinear Control Loop 20vrng

The instrument is set for 10V 1 kHz operation. Signal ERROR INT. OUT on the Oscillator Control assembly is measured via the SDL line to be 0V ±5.0V. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3416 A12/A13: DAC 15th Bit Fault

The instrument is set for 1V 1 kHz operation. Bit 14 of the 15 BIT DAC is checked. A failure indicates the Oscillator Control assembly (A12) is probably at fault. Check FET Q19.

3417 A12: DC Sensor Buffer Fault

The instrument is set for 1V 1 kHz operation. The output of the DC Sense Buffer, on the Oscillator Control assembly, is measured via the RCL line. This measurement is done by comparing it to the DAC assembly output voltage. The difference is measured to be 0V ±500 µV. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3418 A12: Sensor Loop/SQ. Root Amp Fault

The instrument is set for 2.19V 1 kHz operation. The output of the DC Sense Buffer is connected to the main ac/dc sensor on the Oscillator Control assembly. The output of the main sensor is measured via the RCL line by comparing it to the DAC assembly output voltage. The difference is measured to be 0V ±100 mV. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3419 A12: AC Sensor Buff (2V Range)

The instrument is set for 2.19V 1 kHz operation. The output of the AC Sense Buffer is connected to the main ac/dc sensor on the Oscillator Control assembly. The output of the main sensor is measured via the RCL line by comparing it to the DAC assembly output voltage. The difference is measured to be 0V ±160 mV. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3420 A12: AC Sensor Buff (20V Range)

The instrument is set for 21.9V 1 kHz operation. The output of the AC Sense Buffer is connected to the main ac/dc sensor on the Oscillator Control assembly. The output of the main sensor is measured via the RCL line by comparing it to the DAC assembly output voltage. The difference is measured to be 0V ±160 mV. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3421 A12: AC Cal Sensor (2V Range)

The instrument is set for 2.19V 1 kHz and configured as in the 2V range ac/ac calibration. The output of the ac/ac sensor on the Oscillator Control assembly is measured via the RCL line. The output of this ac/ac sensor is measured by comparing it to the DAC assembly output voltage. The difference is measured to be 0V ±100 mV. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3422 A12: AC Cal Sensor (20V Range)

The instrument is set for 21.9V 1 kHz and configured as in the 20V range ac/ac calibration. The output of the ac/ac sensor on the Oscillator Control assembly is measured via the RCL line. The output of this ac/ac sensor is measured by comparing it to the DAC assembly output voltage. The difference is measured to be 0V ±100 mV. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3423 Assembly A12 Missing

At power up the instrument checks to see what assemblies are not installed. This test confirms that the Oscillator Control assembly is not responding. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3424 Assembly A13 Missing

At power up the instrument checks to see what assemblies are not installed. This test confirms that the Oscillator Output assembly is not responding. A failure indicates the Oscillator Output assembly (A13) is probably at fault.

3425 Assembly A12 Or A13 Not Responding

Communication with both Oscillator assemblies is checked. A failure indicates that one or both assemblies are not responding.

3426 A12: 8255 Was Reset

The control word of the 8255 on the Oscillator Control assembly is read. A failure indicates the Oscillator Control assembly (A12) is probably at fault.

3427 A13: 8255 Was Reset

The control word of the 8255 on the Oscillator Output assembly is read. A failure indicates the Oscillator Output assembly (A13) is probably at fault.

3500 A16: 8255 Control Word

The diagnostics software reads the control word of the 8255 IC on the Power Amp assembly. A failure indicates the Power Amp assembly (A16) is probably at fault.

3501 A16: 8255 Port A

The diagnostics software writes and reads data to port A of the 8255 IC on the Power Amp assembly. A failure indicates the Power Amp assembly (A16) is probably at fault.

3502 A16: 8255 Port B

The diagnostics software reads port B of the 8255 IC on the Power Amp assembly. A failure indicates the Power Amp assembly (A16) is probably at fault.

3503 A16: 8255 Port C

The diagnostics software read port C of the 8255 IC on the Power Amp assembly. A failure indicates the Power Amp assembly (A16) is probably at fault.

3504 Spare

This fault code is not used.

3505 Spare

This fault code is not used.

3506 Spare

This fault code is not used.

3507 A16: PA Supplies Are Off

The instrument is dormant. The +PA and -PA supplies are measured by connecting MUX1 and MUX2 respectively to the SDL line where they are measured by the adc circuit on the DAC assembly. This failure occurs if the measured voltage is between 40-80V. The test switch S201 on the Filter/PA Supply assembly (A18) appears to be in the test position.

3508 A16/A14: 220V AC Range Output Fault

The instrument is configured for operation at 22.1V at 1 kHz, 22.1V at 100 Hz, 100V at 1 kHz, 100V at 80 Hz, 100V at 500 Hz, 219V at 1 kHz, and 219V at 50 Hz. The output of the Power Amplifier is routed to the High Voltage Control assembly where it is divided and converted to a dc voltage by a peak detector circuit. This dc voltage which is equal to the peaks of the ac amplitude is connected to the SDL line where it is measure by the adc circuit on the DAC assembly to be the nominal ±10%. Exit diagnostics and set the instrument for the previous configuration and using a DMM measure the ac voltage output of the Power Amplifier, COM=TP10 HI=TP6. If the voltage is out of tolerance the Power Amplifier assembly (A16) is probably at fault. If the voltage is within tolerance, the the High Voltage Control assembly (A14) is probably at fault.

3509 A16: Amplifier Loop Not Regulated

The instrument is configured into three modes of operation. The first two modes is with the instrument set to the dc 220V range. The first is with the Power Amplifier input voltage being the 6.5V reference voltage (BRF6, BSRF6) resulting in a -130V Power Amplifier output. The second is the normal 220V dc operation with the input voltage from the DAC assembly. In this mode the Power Amplifier is outputting 22.1V, 100V, 219V, and -219V. The third is the ac 220V range at 22.1V at 1 kHz, 22.1V at 100 Hz, 100V at 1 kHz, 100V at 80 Hz, 100V at 500 Hz, 219V at 1 kHz, and 219V at 50 Hz. The output of the Power Amplifier input stage is measure to be less than 11V by connecting MUX0 to the SDL line where it is measured by the adc circuit on the DAC assembly. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3510 A16: 220V Amp Fault

The instrument is set to the dc 220V range with two modes of operation. The first is with the Power Amplifier input voltage being the 6.5V reference voltage (BRF6, BSRF6) resulting in a -130V Power Amplifier output. The second is the normal 220V dc operation with the input voltage from the DAC assembly. In this mode the Power Amplifier is outputting 22.1V, 100V, 219V, and -219V. In each mode the Power Amplifier output voltage is measured to be the nominal ±10% by connecting MUX3 to the SDL line where it is measured by the adc circuit on the DAC assembly. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3511 A16: Incorrect PA Input

The instrument is set to the dc 220V range with two modes of operation. The first is with the Power Amplifier input voltage being the 6.5V reference voltage (BRF6, BSRF6) resulting in a -130V Power Amplifier output. The second is the normal 220V dc operation with the input voltage from the DAC assembly. In this mode the Power Amplifier is outputting 22.1V, 100V, 219V, and -219V. The 6.5V reference input or the resulting -1.105V, -5.0V, -10.95V, and 10.95V respectively from the DAC, is measured to be the nominal ±10% by connecting MUX5 to the SDL line where it is measured by the adc circuit on the DAC assembly. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3512 Spare

This fault code is not used.

3513 Spare

This fault code is not used.

3514 Spare

This fault code is not used.

3515 Spare

This fault code is not used.

3516 Spare

This fault code is not used.

3517 Spare

This fault code is not used.

3518 Spare

This fault code is not used.

3519 Spare

This fault code is not used.

3520 A16: PA Oven Regulation Fault

The heater voltage of the Power Amp hybrid is measured by connecting MUX7 to the SDL line where it is measured by the adc circuit on the DAC assembly to ensure the hybrid is warmed up and regulating. The heater voltage is measured to be 0.7V ±10% ±0.2V. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3521 Assembly A16 Is Not Responding

At power up the instrument checks to see what assemblies are not installed. This test verifies that the Power Amplifier is not responding. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3522 Spare

This fault code is not used.

3523 Spare

This fault code is not used.

3524 A16: Power Amp Is Too Hot

The temperature of the Power Amp assembly is checked by connecting the output of the Temperature Sensor (MUX4) to the SDL line where it is measured by the adc circuit on the DAC assembly. This fault occurs if the measured voltage is over 1.7V. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3525 220V DC Initialization Fault

This fault occurs if the diagnostics software was unable to properly set the Power Amplifier assembly hardware for diagnostics testing. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3526 220V AC Initialization Fault

This fault occurs if the diagnostics software was unable to properly se the Power Amplifier assembly hardware for diagnostics testing in the AC mode. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3527 A16: Power Amp DC Cal Network Zero Fault

The instrument is dormant. The offset of the 220V DC INT. CAL NETWORK circuit on the Power Amplifier is measured by connecting its input to ACOM and the output is connected to the RCL line. RCL is routed to the +input of the adc circuit on the DAC assembly and the -input is connected to the DAC output which is adjusted until a null is achieved. This fault occurs if the DAC assembly was unable to converge. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3528 A16: Power Amp DC Cal Network Gain Fault

The instrument is dormant. The gain of the 220V INT. CAL NETWORK circuit on the Power Amplifier is measured by connecting its input to the 13V reference (BRF13, BSRF13) and the output is connected to the RCL line. RCL is routed to the +input of the adc circuit on the DAC assembly and the -input is connected to the DAC output which is adjusted until a null is achieved. This fault occurs if the nominal gain of 0.125 is over 7%. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3529 A16: Power Amp 220V Range Attenuator Fault

The Power Amplifier is configured to the dc 220V range with the input voltage being the 6.5V reference BRF6 and BSRF6. The resulting -130V at the output is connected to the input of the 220V RANGE AC ATTENUATOR circuit which has a nominal gain of -.01. The resulting +1.3V at its output is measured to be within 10% by connecting it to the RCL line and routing it to the +input of the adc circuit on the DAC assembly. The DAC output is connected to the -input and adjusted until a null is achieved. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3530 A16: 8255 Was Reset

The control word of the 8255 on the Power Amplifier is read. A failure indicates the Power Amplifier assembly (A16) is probably at fault.

3600 +17S Supply Fault

The instrument is dormant and the +17 S supply is out of tolerance. Measure the +17 S voltage on the Regulator/Guard Crossing assembly (A17). COM = TP9, HI = TP8. The voltage should be +17.0V to +18.0V. If the voltage is out of tolerance, the Regulator/Guard Crossing assembly (A17) is faulty. If the voltage is within tolerance, the diagnostic circuit on the Switch Matrix assembly (A8) is faulty.

3601 -17S Supply Fault

The instrument is dormant and the -17 S supply is out of tolerance. Measure the -17 S voltage on the Regulator/Guard Crossing assembly (A17). COM = TP9, HI = TP12. The voltage should be -17.0V to -18.7V. If the voltage is out of tolerance, the Regulator/Guard Crossing assembly (A17) is faulty. If the voltage is within tolerance, the diagnostic circuit on the Switch Matrix assembly (A8) is faulty.

3602 +15S Supply Fault

The instrument is dormant and the +15 S supply is out of tolerance. Measure the +15 S voltage on the Regulator/Guard Crossing assembly (A17). COM = TP9, HI = TP18. The voltage should be +14.2V to +15.8V. If the voltage is out of tolerance, the Regulator/Guard Crossing assembly (A17) is faulty. If the voltage is within tolerance, the diagnostic circuit on the Oscillator Output assembly (A13) is faulty.

3603 -15S Supply Fault

The instrument is dormant and the -15 S supply is out of tolerance. Measure the -15 S voltage on the Regulator/Guard Crossing assembly (A17). COM = TP9, HI = TP19. The voltage should be -14.2V to -15.8V. If the voltage is out of tolerance, the Regulator/Guard Crossing is faulty. If the voltage is within tolerance, the diagnostic circuit on the Oscillator Output assembly (A13) is faulty.

3604 +42S Supply Fault

The instrument is dormant and the +44 S supply is out of tolerance. Measure the unregulated +44 S voltage on the Filter/PA Supply assembly (A18). COM = TP22, HI = TP7. The voltage should be +45V to +75V. If the voltage is out of tolerance, the Filter/PA Supply assembly (A18) is faulty. If the voltage is within tolerance, measure the regulated +44 S on the Regulator assembly. (A17) COM = TP9, HI = TP13. The voltage should be +42.0V to +45.6V. If the voltage is out of tolerance, the Regulator/Guard

Crossing assembly (A17) is faulty. If the voltage is within tolerance, the diagnostic circuit on the Oscillator Output assembly (A13) is faulty.

3605 -42S Supply Fault

The instrument is dormant and the -44 S supply is out of tolerance. Measure the unregulated -44 S voltage on the Filter/PA Supply assembly (A18). COM = TP22, HI = TP9. The voltage should be -45V to -75V. If the voltage is out of tolerance, the Filter/PA Supply assembly (A18) is faulty. If the voltage is within tolerance, measure the regulated -44 S on the Regulator assembly. (A17) COM = TP9, HI = TP16. The voltage should be -42.0V to -45.6V. If the voltage is out of tolerance, the Regulator/Guard Crossing assembly (A17) is faulty. If the voltage is within tolerance, the diagnostic circuit on the Oscillator Output assembly (A13) is faulty.

3606 LH Com Ground Fault

The Current/Hi Res assembly (A7) connects LHCOM to the SDL line where it is measured by the adc circuit on the DAC assembly for 0V ±50 mV relative to RCOM.

3607 -5lH Supply Fault

The instrument is dormant and the -5 LH supply is out of tolerance. Measure the unregulated -5 LH voltage on the Filter/PA Supply assembly (A18). COM = TP3, HI = TP6. The voltage should be -8V to -16V. If the voltage is out of tolerance, the Filter/PA Supply assembly (A18) is faulty. If the voltage is within tolerance, measure the regulated -5 LH on the Regulator assembly. (A17) COM = TP10, HI = TP15. The voltage should be -4.7V to -5.3V. If the voltage is out of tolerance, the Regulator/Guard Crossing assembly (A17) is faulty. If the voltage is within tolerance, the diagnostic circuit on the Switch Matrix assembly (A8) is faulty.

3608 +5rLH Supply Fault

The instrument is dormant and the +5 RLH supply is out of tolerance. Measure the +5 RLH voltage on the Regulator/Guard Crossing assembly (A17). COM = TP10, HI = TP14. The voltage should be +4.9V to +5.5V. If the voltage is out of tolerance, the Regulator/Guard Crossing assembly (A17) is faulty. If the voltage is within tolerance, the diagnostic circuit on the Switch Matrix assembly (A8) is faulty.

3609 +8RLH Supply Fault

The instrument is dormant and the +8RLH supply is out of tolerance. Measure the +8RLH voltage on the Regulator /Guard Crossing assembly (A17). COM = TP10, HI = TP17. The voltage should be +10V to +20V. If the voltage is out of tolerance, replace fuse F1 on the Regulator/Guard Crossing assembly. (A17) If the voltage is within tolerance, the diagnostic circuit on the Switch Matrix assembly (A8) is faulty.

3610 +PA Supply Fault

The instrument is configured to the dc 220V range. The Power Amplifier is set for 22.1V, 219V, and -219V and the +PA supply is measured for the nominal +180V and +360V ±10% by connecting MUX1 to the SDL line which is measured by the adc circuit on the DAC assembly. In order to identify the faulty assembly the +PA supply will have to be measured. Power off the instrument and remove the Power Amplifier assembly from the chassis.

Note

All of the following connections and measurements aredone on the Filter/PA Supply assembly (A18) in order toverify operation of the +PA supply.

Connect DMM COM to TP203 and the high to TP201. Using a jumper, connect TP207 to TP203 and power on the instrument. The DMM should read +180V ±10%. Using another jumper connect TP205 to TP203. The DMM should read +360V ±10%. If either voltage is out of tolerance the Filter/PA Supply assembly (A18) is probably at fault. If the voltages are within tolerance, the Power Amplifier assembly (A16) is probably at fault.

3611 -PA Supply Fault

The +PA supply is set to +180V and +360V and measured at each setting to be within 10% of the nominal. Reset the instrument. Measure the logic level of TP205 and TP207 on the Filter/PA Supply assembly (A18). TP205 should be a logic high (8V) and TP207 should be a logic low. If these logic levels are incorrect the Digital Control circuit on the Power Amplifier assembly (A16) is faulty. If these logic levels are correct measure the +PA supply on the Filter/PA Supply assembly. COM = TP203, HI = TP201. The voltage should be 180V ±10%. If the voltage is out of tolerance, the Filter/PA Supply assembly (A18) is probably at fault. If the voltage is within tolerance, call up 200V via the instrument keyboard. The +PA supply should go the 360V ±10%. If the voltage is within tolerance, the diagnostic circuit on the Power Amplifier assembly (A16) is probably at fault. If the voltage is out of tolerance, check TP205 on the Filter/PA Supply assembly for a logic low before assuming the Filter/PA Supply assembly is at fault.

3612 +15 OSC Supply Fault

The instrument is dormant and the +15 OSC supply is measured to be within +14.2 to +15.8V. Measure the unregulated +15 OSC voltage on the Filter/PA Supply assembly (A18). COM = TP4, HI = TP2. The voltage should be +19V to +35V. If the voltage is out of tolerance, the Filter/PA Supply assembly (A18) is faulty. If the voltage is within tolerance, measure the regulated +15 OSC on the Regulator assembly (A17). COM = TP4, HI = TP3. The voltage should be +14.2V to +15.8V. If the voltage is out of tolerance, the Regulator/Guard Crossing assembly (A17) is faulty. If the voltage is within tolerance, the diagnostic circuit on the Oscillator Control assembly (A12) is faulty.

3613 -15 OSC Supply Fault

The instrument is dormant and the -15 OSC supply is measured to be within -14.2 to -15.8V. Measure the unregulated -15 OSC voltage on the Filter/PA Supply assembly (A18). COM = TP4, HI = TP5. The voltage should be -19V to -35V. If the voltage is out of tolerance, the Filter/PA Supply assembly (A18) is faulty. If the voltage is within tolerance, measure the regulated -15 OSC on the Regulator assembly (A7). COM = TP4, HI = TP5. The voltage should be -14.2V to -15.8V. If the voltage is out of tolerance, the Regulator/Guard Crossing assembly (A17) is faulty. If the voltage is within tolerance, the diagnostic circuit on the Oscillator Control assembly (A12) is faulty.

3614 OSC Com Ground Fault

The Oscillator Control assembly (A12) connects OSC COM to the SDL line where it is measured by the adc circuit on the DAC assembly for 0V ±50 mV relative to RCOM.

3615 S Com Ground Fault

The Current/Hi Res assembly (A7) connects SCOM to the SDL line where it is measured by the adc circuit on the DAC assembly for 0V ±50 mV relative to RCOM.

3700 A21: 8255 Control Word

The diagnostics software reads the control word of the 8255 IC on the Rear Panel assembly. A failure indicates the Rear Panel assembly (A21) is probably at fault.

3701 A21: 8255 Port A Fault

The diagnostics software writes and reads data to port A of the 8255 IC on the Rear Panel assembly. A failure indicates the Rear Panel assembly (A21) is probably at fault.

3702 A21: 8255 Port B Fault

The diagnostics software reads port B of the 8255 IC on the Rear Panel assembly. A failure indicates the Rear Panel assembly (A21) is probably at fault.

3703 A21: 8255 Port C Fault

The diagnostics software read port C of the 8255 IC on the Rear Panel assembly. A failure indicates the Rear Panel assembly (A21) is probably at fault.

3704 Assembly A21 Not Responding

At power up the instrument checks to see what assemblies are not installed. This test verifies that the Rear Panel is not responding. A failure indicates the Rear Panel assembly (A21) is probably at fault.

3705 A21: Rear Panel Data Bus Fault

The diagnostics software writes and reads from a register in the DUART on the Rear Panel assembly. A failure indicates the Rear Panel assembly (A21) is probably at fault.

3706 Spare

This fault code is not used.

3707 Spare

This fault code is not used.

3708 A21: 8255 Was Reset

The control word of the 8255 on the Rear Panel assembly is read. A failure indicates the Rear Panel assembly (A21) is probably at fault.

3800 A8: 8255 Control Word

The diagnostics software reads the control word of the 8255 IC on the Switch Matrix assembly. A failure indicates the Switch Matrix assembly (A8) is probably at fault.

3801 A8: 8255 Port A Fault

The diagnostics software writes and reads to port A of the 8255 IC on the Switch Matrix assembly. A failure indicates the Switch Matrix assembly (A8) is probably at fault.

3802 A8: 8255 Port B Fault

The diagnostics software reads port B of the 8255 IC on the Switch Matrix assembly. A failure indicates the Switch Matrix assembly (A8) is probably at fault.

3803 A8: 8255 Port C Fault

The diagnostics software reads port C of the 8255 IC on the Switch Matrix assembly. A failure indicates the Switch Matrix assembly (A8) is probably at fault.

3804 A8: Zero Amp Lo Noise Fault

The Internal Cal Zero Amplifier circuit on the Switch Matrix assembly is tested for noise in the low gain configuration. This is done by connecting the circuit input to RCOM, by turning on Q7, and connecting the output to the RCL line where it is measured by the adc circuit on the DAC assembly. The adc circuit takes ten readings and this failure occurs if the difference between the lowest value and highest value of the ten readings is over 0.0001V. A failure indicates the Switch Matrix assembly (A8) is probably at fault.

3805 A8: Zero Amp Lo Offset

The Internal Cal Zero Amplifier circuit on the Switch Matrix assembly is tested for excessive offset in the low gain configuration. This is done by connecting the circuit input to RCOM, by turning on Q7, and connecting the output to the RCL line where it is measured by the adc circuit on the DAC assembly. The adc circuit takes ten readings and this failure occurs if the average value is over 0.035V. A failure indicates the Switch Matrix (A8) assembly is probably at fault.

3806 A8: Zero Amp Lo Gain Fault

The gain of the Internal Cal Zero Amplifier circuit in the low gain (10) configuration is tested. The circuit input is connected to the output of the DAC assembly and the circuit output is connected to the RCL line. The RCL line is connected to the +input of the adc circuit and the -input is connected to the 6.5V reference. The gain of the Internal Cal Zero Amplifier is determined by setting the DAC output to the nominal 0.65V and then adjusted it until a null is achieved. The gain is tested to be 10 ±6%. A failure indicates the Switch Matrix (A8) assembly is probably at fault.

3807 A8: Zero Amp Hi Noise Fault

The Internal Cal Zero Amplifier circuit on the Switch Matrix assembly is tested for noise in the high gain configuration. This is done by connecting the circuit input to RCOM, by turning on Q7, and connecting the output to the RCL line where it is measured by the adc circuit on the DAC assembly. The adc circuit takes ten readings and this failure occurs if the difference between the lowest value and highest value of the ten readings is over 0.0015V. A failure indicates the Switch Matrix (A8) assembly is probably at fault.

3808 A8: Zero Amp Hi Offset

The Internal Cal Zero Amplifier circuit on the Switch Matrix assembly is tested for excessive offset in the high gain configuration. This is done by connecting the circuit input to RCOM, by turning on Q7, and connecting the output to the RCL line where it is measured by the adc circuit on the DAC assembly. The adc circuit takes ten readings and this failure occurs if the average value is over 0.155V. A failure indicates the Switch Matrix (A8) assembly is probably at fault.

3809 A8: Zero Amp Hi Gain Fault

The gain of the Internal Cal Zero Amplifier circuit in the high gain (130) configuration is tested. The circuit input is connected to the output of the DAC assembly and the circuit output is connected to the RCL line. The RCL line is connected to the +input of the adc circuit and the -input is connected to the 6.5V reference. The gain of the Internal Cal Zero Amplifier is determined by setting the DAC output to the nominal 0.05V and then adjusted it until a null is achieved. The gain is tested to be 130 ±6%. A failure indicates the Switch Matrix (A8) assembly is probably at fault.

3810 A8: 2.2V Amp Noise Fault

3811 A8: Zero Amp Offset

3812 A8: 2.2V Gain Fault

3813 A8: 220mV Offset Fault

3814 A8: 220mV Divider Fault

3815 A8: 22mV Divider Fault

3816 Spare

This fault code is not used.

3817 Spare

This fault code is not used.

3818 A8: Out Lo To Sense Lo Continuity Fault

3819 A8: Relay Fault

A fault occurred while doing relay testing on the Switch Matrix assembly.

3820 Spare

This fault code is not used.

3821 Spare

This fault code is not used.

3822 Spare

This fault code is not used.

3823 Spare

This fault code is not used.

3824 A8: Oven Regulation Fault

The heater voltage of the Switch Matrix HR1 hybrid assembly is measured to ensure it is warmed up and regulating by connecting OVEN TEMP to the SDL line where it is measured by the adc circuit on the DAC assembly. OVEN TEMP is measured to be 0.7V ±10% ±0.2V. A failure indicates the Switch Matrix (A8) assembly is probably at fault.

3825 Assembly A8 Not Responding

At power up the instrument checks to see what assemblies are not installed. This test verifies that the Switch Matrix assembly is not responding. A failure indicates the Switch Matrix (A8) assembly is probably at fault.

3826 A8: 8255 Was Reset

The control word of the 8255 on the Switch Matrix assembly is read. A failure indicates the Switch Matrix (A8) assembly is probably at fault.

3827 Assembly A8 Too Hot

3900 A5: 8255 Control Word

The diagnostics software reads the control word of the 8255 IC on the Wideband Output assembly. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3901 A5: 8255 Port A Fault

The diagnostics software writes and reads data to port A of the 8255 IC on the Wideband Output assembly. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3902 A5: 8255 Port B Fault

The diagnostics software reads port B of the 8255 IC on the Wideband Output assembly. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3903 A5: 8255 Port C Fault

The diagnostics software reads port C of the 8255 IC on the Wideband Output assembly. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3904 Optional Assemblies A5/A6 Are Missing

At power up the instrument checks to see what assemblies are not installed. This test verifies that the Wideband Output is not responding. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3905 A6: Phase Lock Loop At 10MHz

The Wideband assemblies are configured to 3.5V at 1.3 MHz, 1.2V at 1.3 MHz, 2.0V at 3.0 MHz, 1.0V at 4.1 MHz, 3.3V at 5.0 MHz, 2.0V at 6.0 MHz, 2.0V at 7.0 MHz, and 2.0V at 7.9 MHz. The input voltage to the VCO circuit on the Wideband Oscillator assembly is resistively divided creating WB PLL DIAGNOSTICS which is routed to the Wideband Output assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly. This fault occurs if the input voltage to the VCO is not within 25% ±0.75V of the expected value. A failure indicates the Wideband Oscillator (A6) assembly is probably at fault.

3906 A6: Phase Lock Loop At 30MHz

The Wideband assemblies are configured to 3.5V at 30.0 MHz and 1.2V at 30.0 MHz. The input voltage to the VCO circuit on the Wideband Oscillator assembly is resistively divided creating WB PLL DIAGNOSTICS which is routed to the Wideband Output assembly where it is connected to the SDL line for measurement by the adc circuit on the DAC assembly. This fault occurs if the input voltage to the VCO is not within 25% ±0.75V of the expected value. A failure indicates the Wideband Oscillator (A6) assembly is probably at fault.

3907 A5: Rms Sensor At 10MHz

The Wideband assemblies are configured to 3.5V at 1.3 MHz, 1.2V at 1.3 MHz, 2.0V at 3.0 MHz, 1.0V at 4.1 MHz, 3.3V at 5.0 MHz, 2.0V at 6.0 MHz, 2.0V at 7.0 MHz, and 2.0V at 7.9 MHz. SENSOR CAL which is the output from the RMS Sensor and Amplitude Control circuit on the Wideband Output assembly is connected to the SDL line for measurement by the adc circuit on the DAC assembly. This fault occurs if RMS Sensor output is not within 15% of the expected value. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3908 A5: Rms Sensor At 30MHz

The Wideband assemblies are configured to 3.5V at 30.0 MHz and 1.2V at 30.0 MHz. SENSOR CAL which is he output from the RMS Sensor and Amplitude Control circuit on the Wideband Output assembly is connected to the SDL line for measurement by the adc circuit on the DAC assembly. This fault occurs if RMS Sensor output is not within 15% of the expected value. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3909 A5: Rms Sensor At 6.5V DC In

The 6.5V reference (BRF6, BSRF6) is connected to the input of the RMS Sensor circuit on the Wideband Output assembly. The nominal 6.5V output of the Sensor is divided and buffered before being measured via the SENSOR CAL line. SENSOR CAL is connected to the SDL line for measurement by the adc circuit on the DAC assembly. This fault occurs if the output of the Sensor is not 6.5V ±0.47V. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3910 A5/A6: Ampl. Control At 10MHz

The Wideband assemblies are configured for a 3.5V and 1.2V output at 1.3 MHz. WB AMPLITUDE CONTROL which is the control signal to the Wideband Oscillator assembly is divided and connected to the SDL line for measurement by the adc circuit on the DAC assembly. At the 3.5V level it is checked to be 4.5V ±1.0V and at the 1.2V level it is checked for 0.0V ±0.7V. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3911 A5/A6: Ampl. Control At 30MHz

The Wideband assemblies are configured for a 3.5V and 1.2V output at 30.0 MHz. WB AMPLITUDE CONTROL which it the control signal to the Wideband Oscillator assembly is divided and connected to the SDL line for measurement by the adc circuit on the DAC assembly. At the 3.5V level it is checked to be 4.8V ±1.0V and at the 1.2V level it is checked for 0.0V ±0.8V. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3912 A5/A6: Output Offset At 10MHz

The Wideband assemblies are configured to 3.5V at 1.3 MHz, 1.2V at 1.3 MHz, 2.0V at 3.0 MHz, 1.0V at 4.1 MHz, 3.3V at 5.0 MHz, 2.0V at 6.0 MHz, 2.0V at 7.0 MHz, and 2.0V at 7.9 MHz. The output of the Unity Gain Amplifier circuit on the Wideband Output assembly is measured via the OUTPUT OFFSET line to ensure the dc offset is less than 20 mV. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3913 A5/A6: Output Offset At 30MHz

The Wideband assemblies are configured to 3.5V at 30.0 MHz and 1.2V at 30.0 MHz. The output of the Unity Gain Amplifier circuit on the Wideband Output assembly is measured via the OUTPUT OFFSET line to ensure the dc offset is less than 20 mV. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3914 A5: 0DB Output Attenuation Fault

The 6.5V reference (BRF6, BSRF6) is connected to the Unity Gain Amplifier circuit on the Wideband Output assembly which drives the output through the Attenuators. The Wideband Output assembly is set for 0 dB attenuation so the 6.5V input results in a 3.25V output into 50Ω. This 3.25V is connected to the RCL line which is routed to the +input of the adc circuit on the DAC assembly. The DAC assembly output is connected to the -input of the adc circuit and adjusted until a null is achieved. This determines the exact value of the Wideband output. This fault occurs if the determined Wideband output is over 6% ±1.0 mV. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3915 A5: 10DB Output Attenuation Fault

The 6.5V reference (BRF6, BSRF6) is connected to the Unity Gain Amplifier circuit on the Wideband Output assembly which drives the output through the Attenuators. The Wideband Output assembly is set for 10 dB attenuation so the 6.5V input results in a 1.027V output into 50Ω. This 1.027V is connected to the RCL line which is routed to the +input of the adc circuit on the DAC assembly. The DAC assembly output is connected to the -input of the adc circuit and adjusted until a null is achieved. This determines the exact value of the Wideband output. This fault occurs if the determined Wideband output is over 6% ±1.0 mV. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3916 A5: 20DB Output Attenuation Fault

The 6.5V reference (BRF6, BSRF6) is connected to the Unity Gain Amplifier circuit on the Wideband Output assembly which drives the output through the Attenuators. The Wideband Output assembly is set for 20 dB attenuation so the 6.5V input results in a 0.325V output into 50Ω. This 0.325V is connected to the RCL line which is routed to the +input of the adc circuit on the DAC assembly. The DAC assembly output is connected to the -input of the adc circuit and adjusted until a null is achieved. This determines the exact value of the Wideband output. This fault occurs if the determined Wideband output is over 6% ±1.0 mV. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3917 A5: 30DB Output Attenuation Fault

The 6.5V reference (BRF6, BSRF6) is connected to the Unity Gain Amplifier circuit on the Wideband Output assembly which drives the output through the Attenuators. The Wideband Output assembly is set for 30 dB attenuation so the 6.5V input results in a 0.103V output into 50Ω. This 0.103V is connected to the RCL line which is routed to the +input of the adc circuit on the DAC assembly. The DAC assembly output is connected to the -input of the adc circuit and adjusted until a null is achieved. This determines the exact value of the Wideband output. This fault occurs if the determined Wideband output is over 6% ±1.0 mV. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3918 A5: 40DB Output Attenuation Fault

The 6.5V reference (BRF6, BSRF6) is connected to the Unity Gain Amplifier circuit on the Wideband Output assembly which drives the output through the Attenuators. The Wideband Output assembly is set for 40 dB attenuation so the 6.5V input results in a 0.032V output into 50Ω. This 0.032V is connected to the RCL line which is routed to the +input of the adc circuit on the DAC assembly. The DAC assembly output is connected to the -input of the adc circuit and adjusted until a null is achieved. This determines the exact value of the Wideband output. This fault occurs if the determined Wideband output is over 6% ±1.0 mV. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3919 Spare

This fault code is not used.

3920 Spare

This fault code is not used.

3921 Spare

This fault code is not used.

3922 A5/A6: Wideband Initialization Fault

This fault occurs if the diagnostics software was unable to properly set the Wideband assembly hardware for diagnostics testing. A failure indicates the Wideband Output (A5) assembly is probably at fault.

3923 A5: 8255 Was Reset

The control word of the 8255 on the Wideband Output is read. A failure indicates the Wideband Output (A5) assembly is probably at fault.

Component-level Troubleshooting 5-3.

Warning

Servicing described in this section is to be performed byqualified service personnel only. To avoid electricalshock, do not perform any servicing unless qualified todo so.

The remaining part of Section 5 is devoted to troubleshooting the Calibrator analog modules to the component level. Use the following information alongside the schematic diagrams as a guide in troubleshooting if you do not wish to replace a faulty module through the Fluke Module Exchange Program. (Refer to Section 1 for module exchange instructions.)

Note

To access the Calibrator assemblies for troubleshooting during operation, you will need the 5700A-7001K Extender Card Kit, Fluke P/N 857409.

Troubleshooting the Wideband Output Assembly (A5) 5-4.

Proceed as follows to troubleshoot the Wideband Output assembly (A5):

1. Install the Wideband Output assembly on the extender card with its large right front shield removed. The rear shield should remain in place. Connect a 50Ω load to the Wideband Output at the type "N" connector on the Calibrator front panel. Power up the Calibrator and call up the Wideband function.

   Note

   All measurements are referenced to SCOM (TP16) and all Calibrator outputs are from the Wideband Option unless otherwise Noted.

2. Check the Oscillator input and the 10 Hz to 1.1 MHz Buffer circuit. Set the Calibrator to 3.5V at 1 kHz operate. Using a DMM measure the ac voltage at TP9 and verify it is 7V ±10%. If a failure is detected, check input relay K1A and its drive circuit. Next using a DMM measure the ac voltage at TP13 and verify it is also 7V ±10%. If a failure is detected, check U11B, Q17, K1B, K3B, K12, and associated components in the 10 Hz to 1.1 MHz Buffer Circuit.
3. Check the Unity Gain Amplifier circuit. Set the Calibrator to 3.5V at 1 kHz operate. Using a DMM measure the ac voltage at TP14 and verify it is 3.5V ±10%. If a failure is detected, check Q11-Q16 and associated components is the Unity Gain Amplifier circuit.
4. Check the RMS Sensor and Amplitude Control circuit during Wideband operation below 12 kHz. Set the Calibrator to 3.5V at 1 kHz, operate mode. Verify that FETs Q2 and Q3 are turned on by measuring the dc voltage at TP5. (It should be +17V ±10%.) If a failure is detected, check U4B and control line PB0. Using a DMM measure and Note the ac voltage at TP7 and verify it is 7V ±10%. Measure the dc voltage at TP1 and verify it is the same as measured at TP7 ±10%. If a failure is detected, check U1, U2, U3, and associated components. Next measure the dc

voltage at TP2 and verify it is 0.317 times the voltage at TP1 ±10%. If a failure is detected, check U5 and associated components.

Note

During Wideband operation, internal software monitors the output and makes corrections or trips the instrument to standby. This internal monitoring can cause problems when attempting to troubleshoot the Wideband Output assembly. If during the following step the Calibrator trips to standby, defeat the monitoring by connecting a jumper from TP9 to TP10 on the DAC assembly.

5. Check the RMS Sensor and Amplitude Control circuit during Wideband operation from 12 kHz to 1.1 MHz. Set the Calibrator to 3.5V at 12 kHz operate. Using a DMM measure and Note the ac voltage at TP7 and verify it is 7V ±10%. Measure the dc voltage at TP1 and verify it is the same as measured at TP7 ±10%. If a failure is detected, check U1, U2, U3, and associated components. Next measure the dc voltage at TP2 and verify it is 0.317 times the voltage at TP1 ±10%. If a failure is detected, check U5 and associated components. Verify that FETs Q2 and Q3 are turned off by measuring the dc voltage at TP5. (It should be -11.4V ±20%.) If the voltage at TP5 is incorrect skip to step 8.
6. Check the WB Amplitude Control line. Remove jumper E3 from the J3 pins and connect an external variable dc reference voltage to TP18 (low to TP19). Set the Calibrator to 3.5V at 12 kHz operate and set the external dc reference voltage to 2V. Using a DMM measure TP3 and verify it is a negative voltage. Next set the external dc reference voltage to 3V and verify TP3 changes to a positive voltage. If a failure is detected, check U12B and associated components.

Note

Remove the external dc reference and replace jumper E3 before continuing.

7. Check the X10 Amplifier circuit. Set the Calibrator to 3.5V at 1.2 Mhz, operate. Connect an Oscilloscope (set for ac coupling) to the input of the X10 Amplifier which is the junction with R46, R47, and R49. Verify the Oscilloscope displays a distortion-free 1.2 MHz sinewave. If a failure is detected, check the cable at J1 and the Wideband Output assembly. Note the amplitude of the input sine wave and move the Oscilloscope probe to TP13 and verify is displays a distortion-free 1.2 MHz sine wave which is ten times larger in amplitude. If a failure is detected check Q4-Q10 and associated components in the X10 Amplifier circuit.
8. Check the Overload Control circuit. Remove jumper E3 from the J3 pins and connect an external variable dc reference voltage to TP18 (low to TP19). Set the Calibrator to 3.5V at 1.2 MHz operate and set the external dc reference voltage to 2V. Connect an Oscilloscope to TP5 and verify it is a negative voltage. Connect a DMM to TP1 and slowly increase the external dc reference in 10 mV steps until the voltage at TP5 goes positive. Verify the voltage at TP1 is 7.7V ±5%. If a failure is detected, check U4A, U4B, VR2, and associated components.

Note

Remove the external dc reference and replace jumper E3 before continuing.

9. Check the Attenuators. Connect a DMM to the 50Ω termination at the Wideband Output type "N" connector on the Calibrator front panel. Set the Calibrator for output

voltages of 3V, 1V, 300 mV, and 30 mV, all at 1 kHz, and verify the DMM read the selected voltage ±5%. If a failure is detected, check K4-K8, Z1, and Z2. Next, connect the supplied output cable and 50Ω terminator to the WIDEBAND connector of the Calibrator front panel. Refer to the 5700A/5720A Series II Operators manual and run Wideband Gain calibration. After the Wideband Gain calibration is complete check the Wideband output at the end of the cable and 50Ω terminator at 3V, 1V, 300 mV, and 30 mV, all at 1 kHz, and verify the output is within 0.2%.

Troubleshooting the Wideband Oscillator Assembly (A6) 5-5.

Proceed as follows to troubleshoot the Wideband Oscillator assembly (A5):

1. Remove the front and rear shields from the Wideband Oscillator assembly and place it up on the extender card. Power up the Calibrator and call up the Wideband function.

Note

All measurements are referenced to SCOM (TP16 or TP17) and all Calibrator outputs are from the Wideband Option unless otherwise Noted.

2. Set the Calibrator to 1V at 1.2 MHz, operate. Connect an oscilloscope to TP10, set it to 500 mV/div at 500 ns/div, and verify it displays a1.2 MHz signal similar to that shown in Figure 5-1. Next, connect a frequency counter to TP10. Set the Calibrator to 2 MHz, 5 MHz, 10 MHz, 20 MHz, and 30 MHz, verify that each frequency is within 0.01% of the nominal. If a failure is detected, proceed with step 3 otherwise skip to step 11.

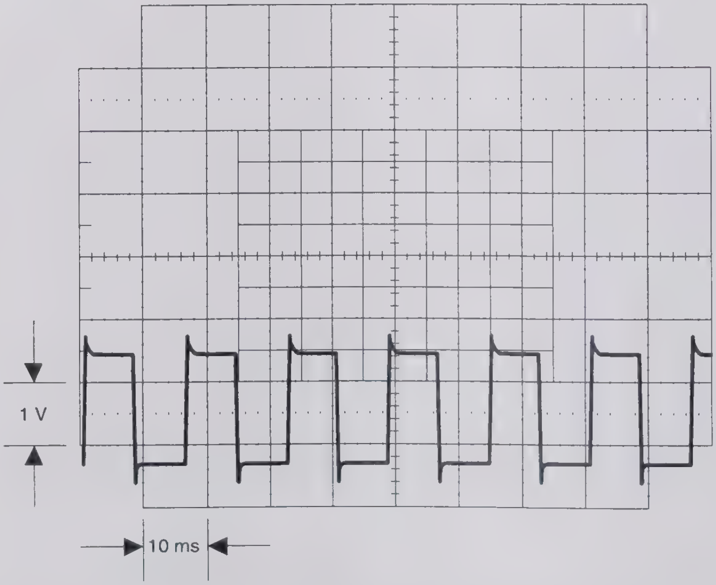

Figure 5-1. Waveform at TP10

3. Check the 8 MHz reference. Set the Calibrator to 1V at 1.2 MHz operate. Connect an oscilloscope to TP1 and verify it displays a 8 MHz signal similar to that shown in Figure 5-2. If a failure is detected, first verify that control line WB ON/OFF* is a

logic high by measuring U15 pin 5. If the signal is incorrect, the control line WB ON/OFF* from the Wideband Output (A5) assembly is probably at fault. If the control line is correct check U15A and associated components.

Note

The input CLK and CLK is a low-level (400 mV p-p) signal generated by the Regulator/Guard Crossing assembly.*

4. Check the 4 MHz to 8 MHz feedback signal. Set the Calibrator to 1V at 1.2 MHz, operate. Connect an oscilloscope to TP15 and verify it displays a 4.8 MHz signal similar to that shown in Figure 5-3. Use a frequency counter and verify that the frequency of this signal is 4.8 MHz ±0.01%. If a failure is detected, continue with step 5; otherwise skip to step 10.

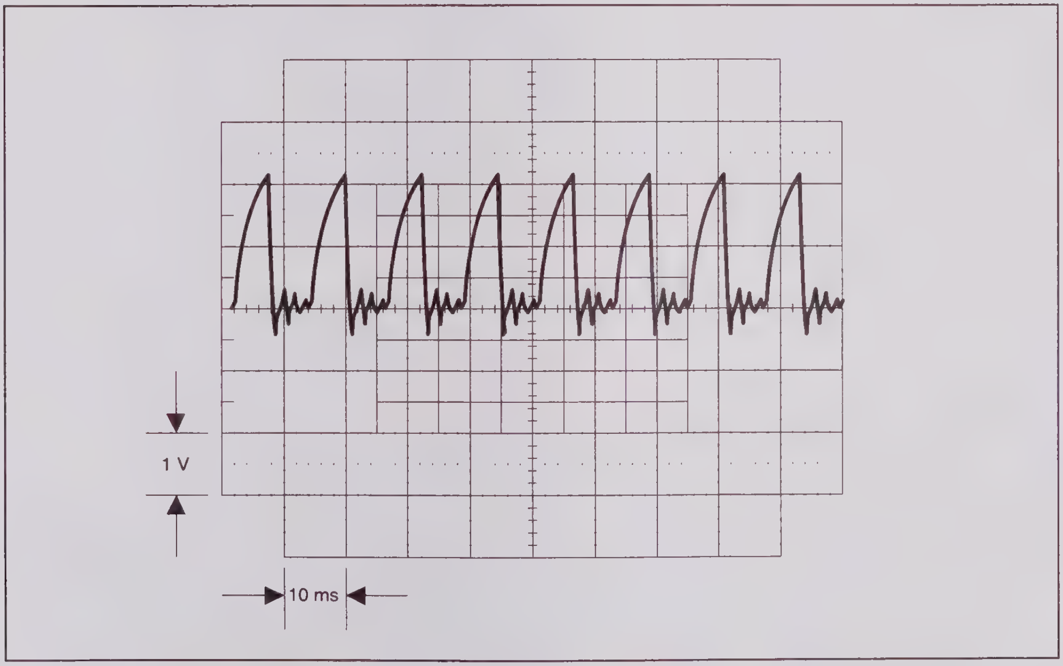

Figure 5-2. Waveform at TP1

5. Check the VCO Supply Voltage. Set the Calibrator to 1V at 1.2 MHz, operate. Using a DMM measure the dc voltage at U3 pin 8 and verify it is -5V ±7%. If a failure is detected, check Q2, Q3, U7, and associated components.
6. Check the VCO circuit. Power down the Calibrator, remove shorting header E6 from the J6 pins, and connect an external variable dc reference(2V to 13V) to TP2. Power up the Calibrator and set it for 1V at 1.2 Mhz, operate. Connect a frequency counter to TP3. Vary the external dc reference from 2 to 12V and verify the frequency counter reading changes from approximately 32 to 64 MHz. If a failure is detected, check the VCO circuit containing U3, CR1, CR2, and associated components.
7. Check the dividers in U4 and U5. Power down the Calibrator, remove shorting header E6 from the J6 pins, and connect an external variable dc reference (2 to 13V) to TP2. Power up the Calibrator and set it for 1V at 1.2 MHz, operate. Connect a

frequency counter to TP3 and adjust the external dc reference until the frequency counter reads 64 MHz ±0.1%. Using the frequency counter, measure the frequency at TP4 and verify it reads 32 MHz ±0.1%. If a failure is detected, check U4 and associated components. Next, measure the frequency at pins 15, 13, 4, and 2 of U5 and verify that pin 15 measures 16 MHz ±0.1%, pin 13 measures 8 MHz ±0.1%, pin 4 measures 4 MHz ±0.1%, and pin 2 measures 2 MHz ±0.1%. If a failure is detected, check U5 and associated components.

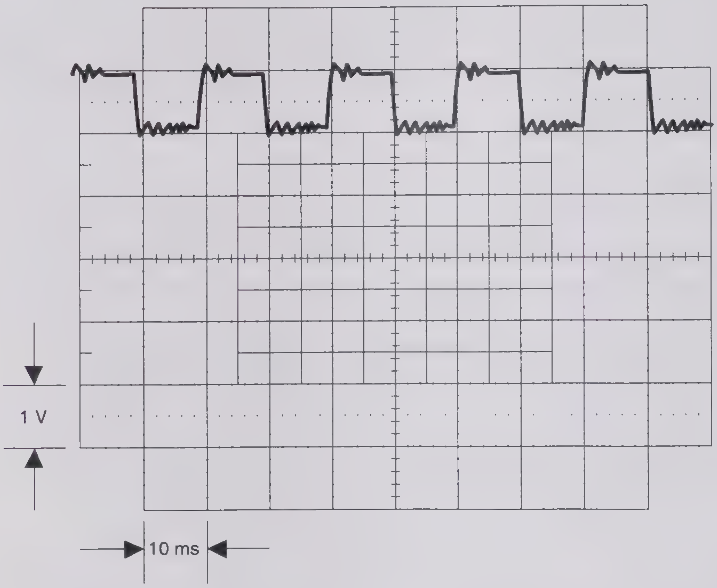

Figure 5-3. Waveform at TP15

8. Check the Synthesizer IC U1. Power down the Calibrator, remove shorting header E6 from the J6 pins, and connect an external variable dc reference (2 to 13V) to TP2. Power up the Calibrator and set it for 1V at 6 MHz, operate. Connect a frequency counter to TP15 and adjust the external dc reference until the counter reads less than 6 MHz (~5.8MHz). Connect an oscilloscope to pin 15 of U1 and verify it displays a signal similar to Figure 5-4. Next, adjust the external dc reference until the counter reads more than 6 MHz (~6.2 MHz).Connect an oscilloscope to pin 14 of U1 and verify it displays a signal similar to Figure 5-4. If a failure is detected, check U1 and associated components.
9. Check the Amplifier Circuit. Power down the Calibrator, remove shorting header E6 from the J6 pins, and connect an external variable dc reference (2 to 13V) to TP2. Power up the Calibrator and set it for 1V at 6 MHz, operate. Connect a frequency counter to TP15 and adjust the external dc reference until the counter reads less than 6 MHz (~5.8 MHz). Connect an oscilloscope to pin 6 of U2 and verify it displays a positive dc voltage. Next, adjust the external dc reference until the counter read more than 6 MHz (~6.2 MHz) and verify the oscilloscope connected to pin 6 of U2 displays a negative dc voltage. If a failure is detected, check U2 and associated components.

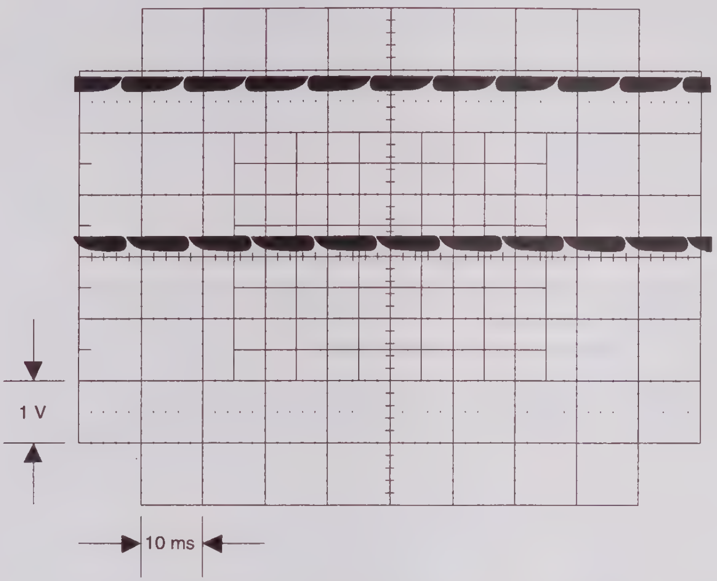

Figure 5-4. Waveform at Pins 14 and 15 of U1

Note

Power down the Calibrator, remove the external dc reference, and replace shorting header E6 on the J6 pins before continuing.

10. Check the Multiplexer U6 and its control lines. Power up the Calibrator and it to 1V at 1.2 MHz, operate. Connect a frequency counter to TP10 and measure the logic levels of the control lines at pins 7, 9, and 10 of U6 using the data in Table 5-1 following table. Verify the logic levels are correct and the output frequency at TP10 is within 0.01%. If a failure is detected, check U6, U7, and associated components.
11. Check the Amplitude Control Amplifier circuit. Disconnect the cable between the Wideband Oscillator assembly and Wideband Output assembly at J1 on the Wideband Output assembly. Set the Calibrator to 1V at 1.2 MHz, operate. Connect an oscilloscope set for ac coupling to pin 6 of U9 and verify it displays a signal similar to Figure 5-5. If a failure is detected, check U9 and its associated components in the Amplitude Control Amplifier circuit.
12. Check the X10 Wideband Amplifier circuit. Disconnect the cable between the Wideband Oscillator assembly and Wideband Output assembly at J1 on the Wideband Output assembly. Set the Calibrator to 1V at 1.2 MHz, operate. Connect an oscilloscope set for ac coupling to TP13 and verify is displays a signal similar to Figure 5-5, but approximately 10 times larger in amplitude. If a failure is detected, check Q4, Q5, Q6, and associated components in the X10 Wideband Amplifier circuit.
13. Check the Filter Select circuit. Disconnect the cable between the Wideband Oscillator assembly and Wideband Output assembly at J1 on the Wideband Output assembly. Set the Calibrator to 1V at 1.2 MHz, 2 Mhz, 4 MHz, 8 MHz, and 16 MHz. At each frequency range verify the collector of the corresponding transistor in U13

switches to a high(~+17V) level while all the others remain at a low (-11V) level. If a failure is detected, check U8, U10, U11, and U13.

14. Check the Filters. Disconnect the cable between the Wideband Oscillator assembly and Wideband Output assembly at J1 on the Wideband Output assembly. Set the Calibrator to 1V at 1.2 MHz, 1.9 MHz, 2 MHz, 3.9 MHz, 4 MHz, 7.9 MHz, 8 MHz, 15.9 MHz, 16 MHz, and 30 Mhz. Connect an oscilloscope to TP14 and verify it displays a distortion-free sine wave at each frequency. If a failure is detected, check the corresponding Filter circuit.

Table 5-1. Verifying Multiplexer U66

5700A/5720A Series II Wideband Output	A Pin 7	B Pin 9	C Pin 10	TP10 1-32 MHz
1.2 Mhz	-5V	-5V	-5V	1.2 MHz
2.0 Mhz	0V	-5V	-5V	2.0 MHz
4.0 Mhz	-5V	0V	0V	4.0 MHz
8.0 Mhz	-5V	-5V	0V	8.0 MHz
16.0 Mhz	0V	0V	-5V	16.0 MHz

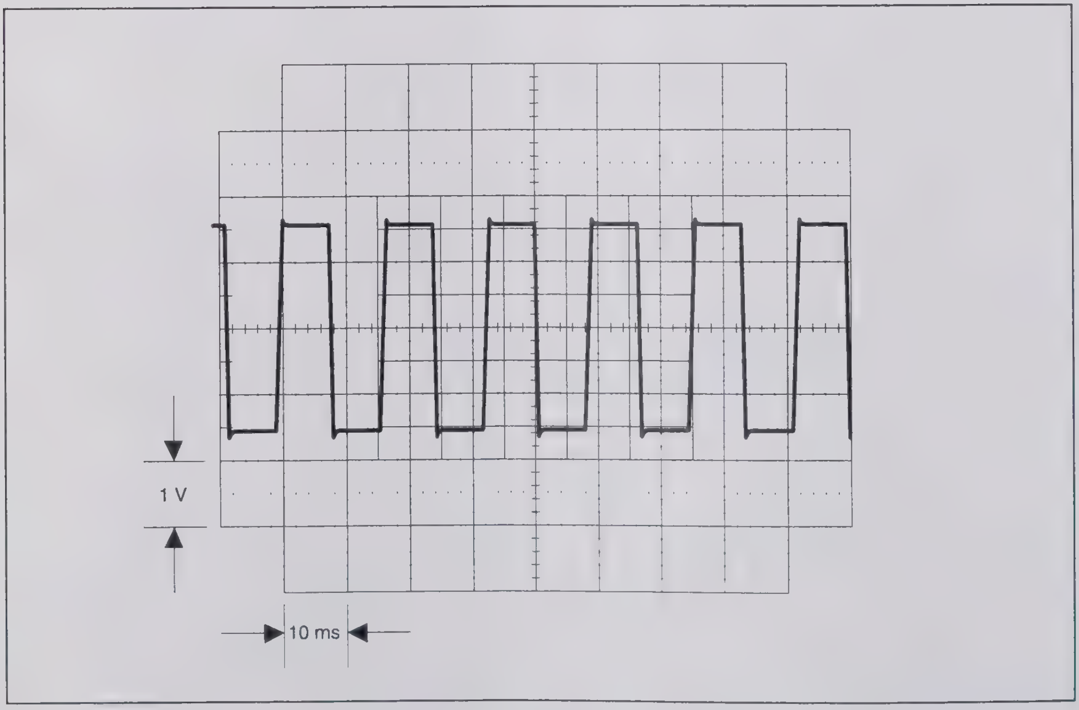

Figure 5-5. Waveform at Pin 6 of U9

Troubleshooting the Current/Hi-Res Assembly (A7) 5-6.

The Current/Hi-Res assembly generates output current and contains the high-resolution oscillator onto which the Oscillator Control assembly phase locks. Since these two functions are independent except for their digital control, troubleshooting procedures for each portion are presented separately.

Current Section 5-7.

Proceed as follows to troubleshoot the current section of the Current/Hi-Res assembly (A7):

1. In order to troubleshoot the Current generating circuitry it is necessary to break the loop and use an external ac reference as the input source. Turn off the Calibrator and cut jumper E1. Connect an external variable ac reference to TP19 (common to TP20).
2. Place the Current/Hi-Res assembly on the analog reverse extender card and jumper the Calibrator OUTPUT HI binding post to the OUTPUT LO binding post. Turn on the Calibrator.

Note

All measurements are referenced to SCOM (TP20) unless otherwise specified.

3. Check the Complimentary Drive Circuit. Set the Calibrator to 200 µA, standby. Set the external ac reference to 7.0V at 1 kHz. Connect an oscilloscope to pin 11 of K2 and verify that it displays a signal similar to Figure 5-6. Connect the oscilloscope to pin 6 of K2 and verify that it displays a signal similar to Figure 5-7. If a failure is detected, check Q2, Q3, Q18, Q19, K2, and their associated components in the Complimentary Drive Circuit.

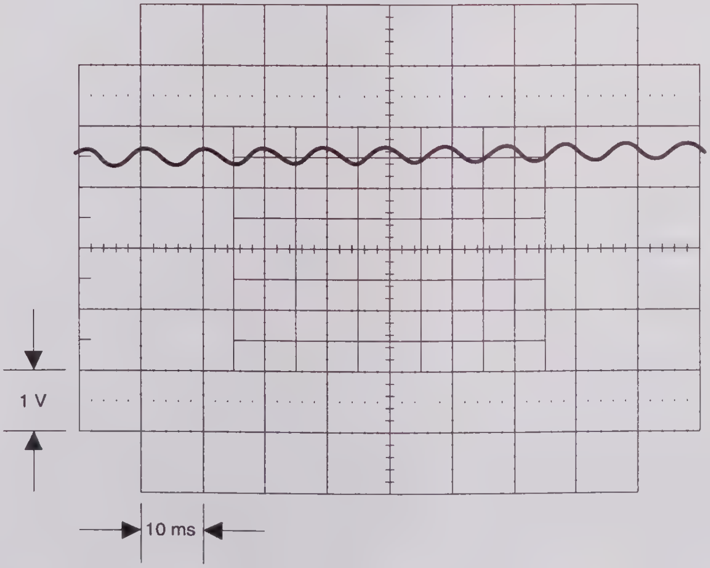

Figure 5-6. Waveform at Pin 11 of K2

4. Check the 220 µA range of the 220 µA/2.2 mA AMP circuit. Set the Calibrator to 200 µA, standby. Set the external ac reference to 6.4V(±0.1V) at 1 kHz. Using a DMM, measure the ac voltage at the collector of Q4 and verify it is 2.0V ac ±10%. If a failure is detected, first verify that the 10 kΩ shunt on HR2 is correct and that it is connected to SCOM thought relays K5C, K5D, K10, K13 and the 1.2Ω load resistor R14 as in Figure 5-8. If the shunt and output switching is correct check Q4, Q5, K3, and the associated components in the 220 µA/2.2 mA AMP circuit.

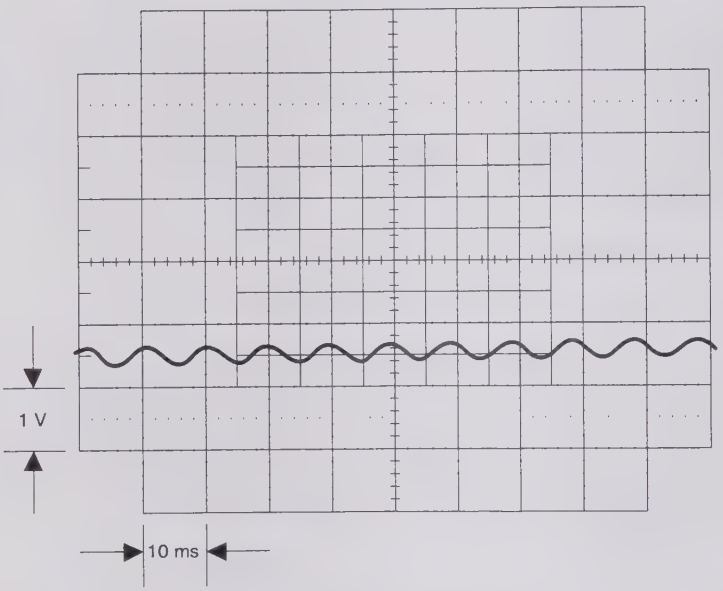

Figure 5-7. Waveform at Pin 6 of K2

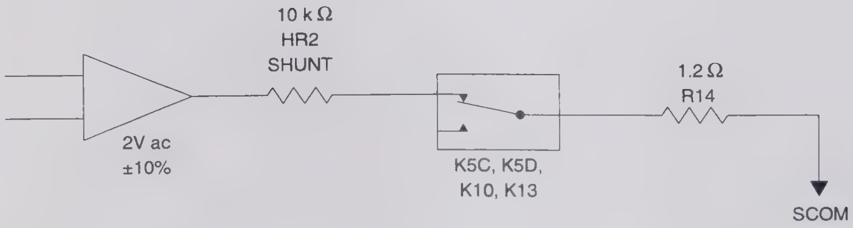

Figure 5-8. Verifying the 220 µA Range of the 220 µA/2.2 mA Amp Circuit

5. Check the 2.2 mA Range of the 220 µA/2.2 mA AMP. Set the Calibrator to 2 mA, standby. Set the external ac reference to 6.4V at 1 kHz. Measure the ac voltage at the collector of Q4 with a DMM and verify it is 2.0V ac ±10%. If a failure is detected, first verify the 1 kΩ shunt on HR2 is correct and it's connected to SCOM through relays in K7A, K5D, K10, K13 and 1.2Ω load resistor R14 as shown in Figure 5-9. If the shunt and output switching is correct check Q4, Q5, K3 and their associated components in the 220 µA /2.2 mA AMP circuit.

6. Check the 22 mA Range of the 22 mA/220 mA AMP. Set the Calibrator to 20 mA, standby. Set the external ac reference to 6.3V (±0.1V) at 1 kHz. Using a DMM measure the ac voltage at the collector of Q6 and verify it is 2.0V ac ±10%. If a failure is detected, first verify the 100Ω shunt on HR2 is correct and is connected to SCOM through relays in K8C, K7A, K5D, K10, K13, and 1.2Ω load resistor R14, as shown in Figure 5-10. If the shunt and output switching are correct, check Q6-Q13, K4, and the associated components in the 22 mA/220 mA AMP circuit.

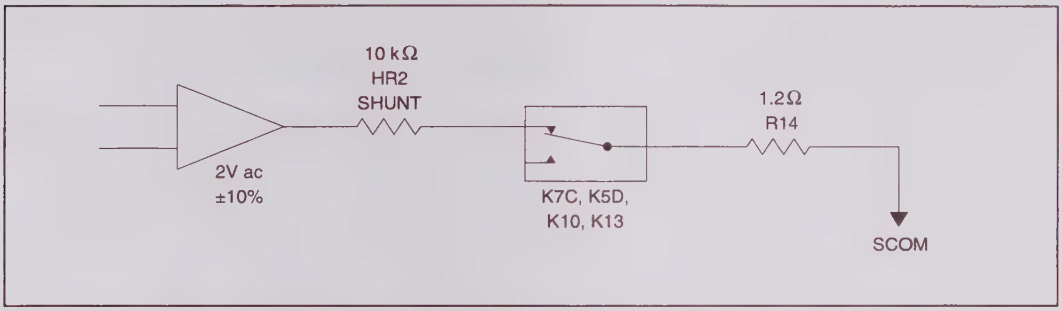

Figure 5-9. Verifying the 2.2 mA Range of the 220 µA /2.2 mA Amp Circuit

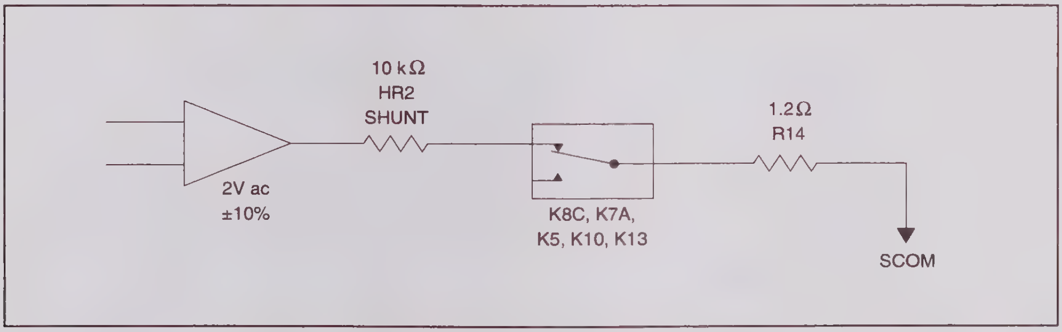

Figure 5-10. Verifying the 22 mA Range of the 22 mA/220 mA Amp Circuit

7. Check the 220 mA Range of the 22 mA/220 mA AMP. Set the Calibrator to 200 mA, standby. Set the external ac reference to 4.6V (±0.1V) at 1 kHz. Using a DMM measure the ac voltage at the collector of Q6 and verify it is 2.0V ac ±10%. If a failure first verify the 10Ω shunt on HR2 is correct and it's connected to SCOM through relays in K9C, K8C, K7A, K5D, K10, K13, and 1.2Ω load resistor R14 as shown in Figure 5-11. If the shunt and output switching are correct, check Q6-Q13, K4, and the associated components in the 22 mA/220 mA AMP circuit.

8. Check the NEG. FB BUFFER. Set the Calibrator to 200 mA, standby. Set the external ac reference to 4.6V at 1 kHz. Using a DMM measure the ac voltage at the collector of Q6 and Note the reading. Next, measure the voltage at TP3 and verify it is the same as the previous Noted reading ±0.01%. If a failure is detected, check U2, K5A, K6A, K8A,K9A and the associated components.

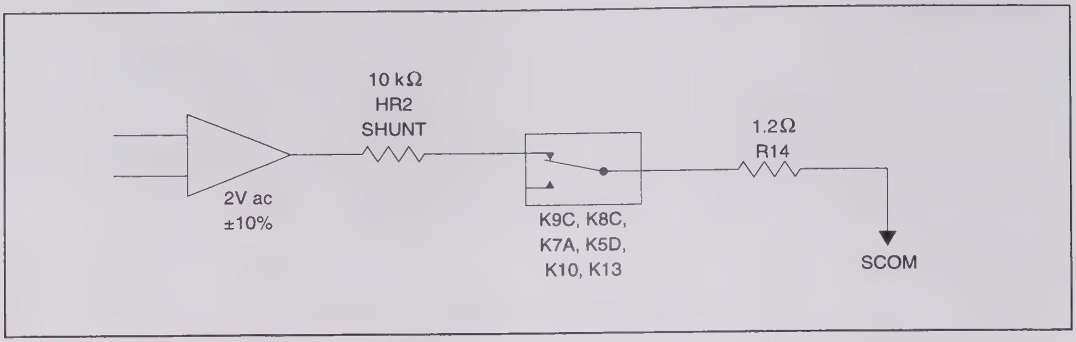

Figure 5-11. Verifying the 220 mA Range of the 22 mA/220 mA Amp Circuit

9. Check the POS. FB BUFFER. Set the Calibrator to 200 mA, standby. Set the external ac reference to 4.6V at 1 kHz. Using a DMM measure the ac voltage at pin 5 of the HR2 resistor network and Note the reading. Next, measure the voltage at TP4 and verify it is the same as the previous Noted reading ±0.1%. If a failure is detected, check U3, K5B, K6B, K8B, K9B, and the associated components.
10. Check the I-GUARD BUFFER. Set the Calibrator to 200 mA, standby. Set the external ac reference to 4.6V at 1 kHz. Measure the ac voltage at TP4 with a DMM and Note the reading. Next, measure the voltage at U4 pin 6 and verify it is the same as the previous Noted reading ±0.01%. If a failure is detected, check U4 and its associated components.

Note

Replace or reconnect jumper E1 and remove the external ac reference from the Current/Hi-Res assembly before continuing.

11. Check the Input Switching. Set the Calibrator to 2 mA dc, operate. Using a DMM, measure the dc voltage at TP1 (common to TP2) and verify it is 20V dc ±0.25%. Next, set the Calibrator to ac 2 mA at 1 kHz operate and measure the ac voltage at TP1 and verify it is 20V ac ±25%. If a failure is detected, check K1, Q20-Q23, and their appropriate drive circuitry.
12. Check the Z1 resistor network. Set the Calibrator to 2 mA dc, operate. Using a DMM measure the dc voltage at pins 8 and 3 of Z1 and verify they are 1.818V dc ±0.35%. If a failure is detected, check Z1 and the HR2 hybrid.
13. Check the CURRENT/COMPLIANCE VOLTAGE MONITOR. Connect a 10Ω 1% resistor across the Calibrator output and set the Calibrator to 200 mA at 1 kHz, operate. Using a DMM measure the ac voltage at the OUT HI binding post and edit the current output until it measures 2.0V ac ±0.01V. Next, measure the dc voltage at TP9 and verify it is 0.238V dc ±10%. If a failure is detected, check U5, U6, and the associated components in the CURRENT/COMPLIANCE VOLTAGE MONITOR circuit.
14. Check the COMPLIANCE LIMITER. Connect a shorting jumper across the Calibrator output and set the Calibrator to 2 mA dc, operate. Using a DMM monitor the dc voltage at TP4. Remove the shorting jumper at the Calibrator output. The voltage at TP4 should not exceed 11V ±5% before the Calibrator trips to standby. If a failure is detected, check Q24, Q25, CR10, CR11, and the associated components in the Compliance Limiter Circuit.

Hi-Res Oscillator Section 5-8.

Proceed as follows to troubleshoot the Hi-Res Oscillator Section of the Current/Hi-Res assembly (A7):

1. Remove the four small shields (two on each side) and place the Current/Hi-Res assembly on the analog reverse extender card. Power up the Calibrator.

Note

All measurements are referenced to LHCOM (TP18).

2. Check the 8 MHz reference. Set the Calibrator to 2V at 1 kHz, operate. Connect an oscilloscope to U13 pin 4 and verify it displays a 8 Mhz signal similar to that shown in Figure 5-12. If a failure is detected, first verify that control line HI-RES ON/OFF is a logic low by measuring U15 pin 12. If not U7 is probably at fault. If this control line is correct check U13 and its associated components.

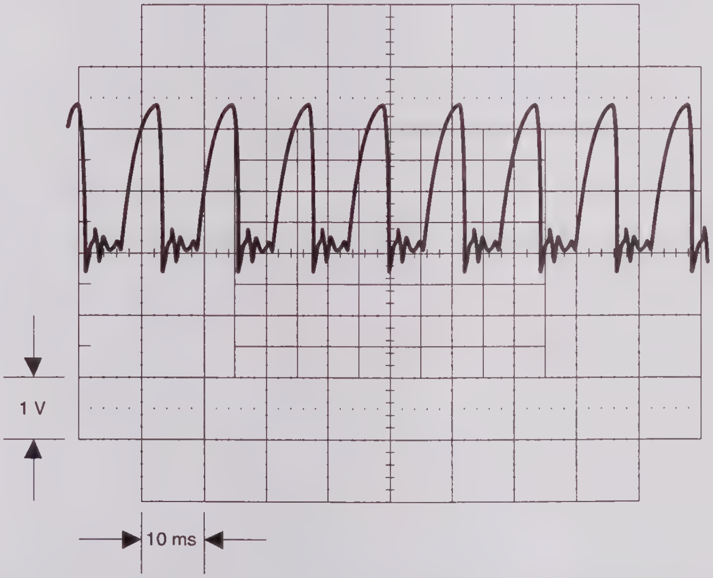

Figure 5-12. Waveform at Pin 4 of U13

Note

The input CLK and CLK is a low level (400 mV p-p) signal generated by the Regulator/Guard Crossing assembly.*

3. Check the 2 MHZ REF. Set the Calibrator to 2V at 1 kHz, operate. Connect an oscilloscope to TP12 and verify it displays a 2 MHz signal similar to that shown in Figure 5-13. If a failure is detected, check U14A and U14B.

4. Check the 6-12 MHZ signal. Set the Calibrator to 2V at 1 kHz, operate. Connect an oscilloscope to TP13 and verify it displays a 10 Mhz signal similar to that shown in Figure 5-14. Also measure the frequency of this signal using a frequency counter and verify it is within 9.999 MHz to 10.001 MHz. If a failure is detected, with either test continue on as follows. If the signal and frequency are correct, skip to step 9.

5. Check VCO Supply Voltage. Set the Calibrator to 2V at 1 kHz, operate. Using a DMM measure the voltage at U19 pin 8 and verify it is -5.25V±7%. If a failure is detected, check U18A, Q15, VR3, and associated components.
6. Check the VCO circuit. Power down the Calibrator, cut jumper E2 and connect an external variable dc reference (2 to 12V) to TP11 (common to TP18). Power up the Calibrator and set it for 2V at 1 kHz. Connect a frequency counter to TP13. Vary the external dc reference from 2 to 12V and verify the frequency counter reading changes from approximately 6 MHz to 12 MHz.

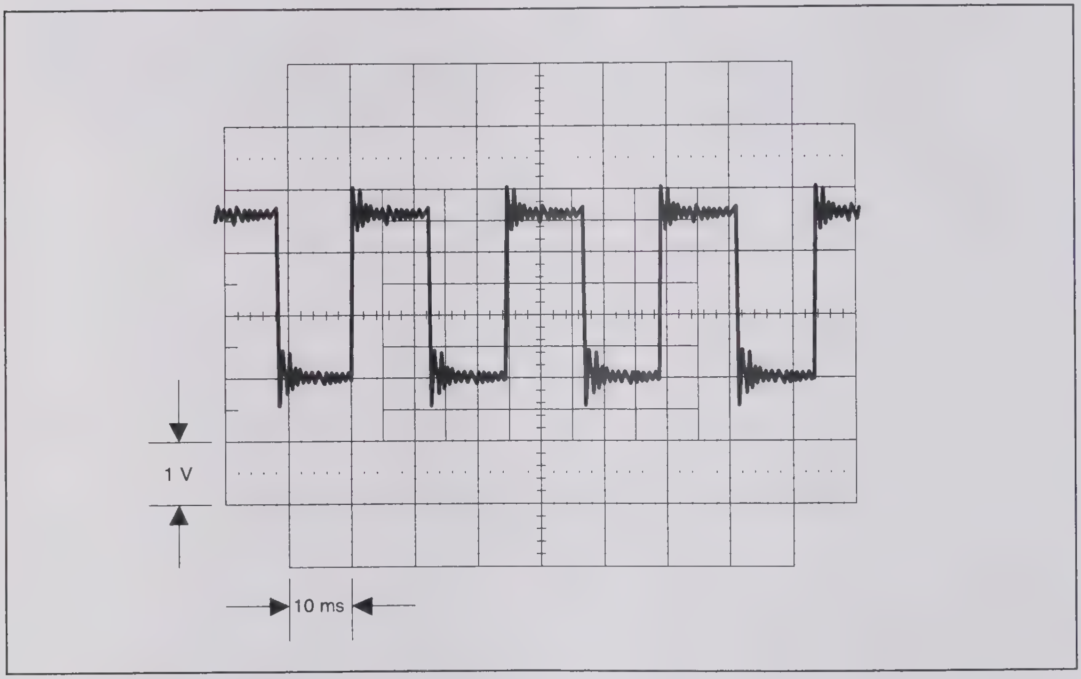

Figure 5-13. Waveform at TP12

Note

The voltage-to-frequency ratio is not important. It is only necessary to verify that a change in voltage causes a change in oscillation frequency. If a failure is detected check U19, CR9, and associated components in the VCO circuit.

7. Check the PHASE DET/DIVIDERS. Power down the Calibrator, cut jumper E2 and connect an external variable dc reference (2 to 12V) to TP11 (common to TP18). Power up the Calibrator and set it for 2V at 1 kHz. Connect a frequency counter to TP13 and adjust the external dc reference so the frequency counter reads less than 10 MHz (~9.8 MHz). Using an oscilloscope, verify that U16 pin 15 (0R) is pulsing and U16 pin 14 (0V) is a logic high. Next, adjust the external dc reference so the frequency counter reads greater than 10 MHz (~10.2 MHz). Using an oscilloscope, verify that U16 pin 14 (0V) is pulsing and U16 pin 15 (0R) is a logic high. If a failure is detected, U16 and/or its digital control is probably at fault.

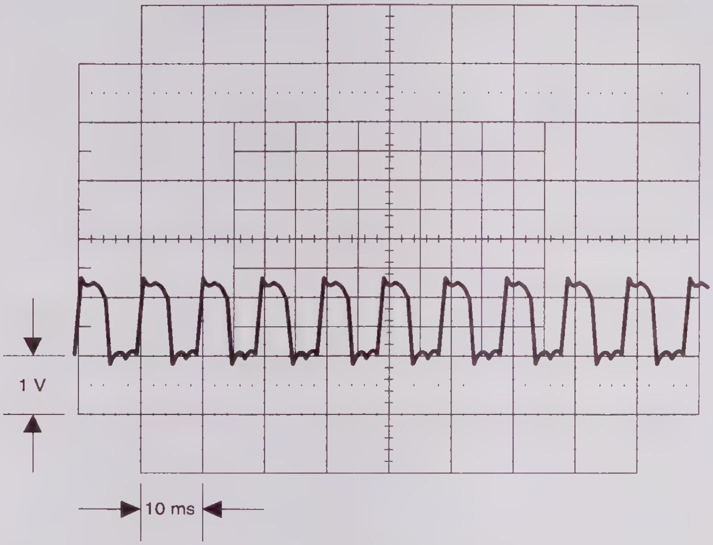

Figure 5-14. Waveform at TP13

8. Check the LOOP FILTER circuit. Power down the Calibrator, cut jumper E2 and connect an external variable dc reference (2 to 12V) to TP11(common to TP18). Power up the Calibrator and set it for 2V at 1 kHz. Connect a frequency counter to TP13 and adjust the external dc reference so the frequency counter read less than 10 MHz (~9.8 MHz).Connect an oscilloscope to U20 pin 7 and verify it displays a positive dc voltage. Next, change the dc reference so the frequency counter reads greater than 10 MHz (~10.2 MHz). At this time U20 pin 7 should be a negative dc voltage. If a failure is detected, check U20A, U20B, and associated components in the LOOP FILTER circuit. Reconnect jumper E2 before continuing.
9. Check the 5-500K Divider. Connect a frequency counter to U21 pin 5. Set the Calibrator to 2V at 1 MHz, 500 kHz, 200 kHz, 140 kHz, 100 kHz, and 50 kHz. At each output frequency verify the frequency counter displays the same as selected ±0.01%. Next, connect the frequency counter to U21 pin 9. Set the Calibrator to 2V at 2 kHz, 120 Hz, and 10 Hz. At each output frequency verify the frequency counter displays the same as the selected ±0.01%. If a failure is detected, check U17 and U21.
10. Check the Output Switching. Connect an oscilloscope and frequency counter to TP16. Set the Calibrator for 2V at 1 kHz, operate, and verify the oscilloscope displays a signal similar to Figure 5-15, and the frequency counter reads 1 kHz ±0.01%. Next, set the Calibrator for 2V at 100 kHz and verify the frequency counter reads 100 kHz ±0.01%. If a failure is detected, check U18B, C, D, U15C, Q16, and associated components.

Troubleshooting the Switch Matrix Assembly (A8) 5-9.

Proceed as follows to troubleshoot the Switch Matrix assembly (A8):

1. The primary function of the Switch Matrix assembly is to connect the output from the various assemblies within the Calibrator to the output binding posts via the Motherboard relays. All relays on the Switch Matrix assembly are latching type.

These relays are latched in the set or reset position and remain in that position even after power has been removed. To troubleshoot the signal path through the Switch Matrix assembly simply set the Calibrator to the function in which a problem is detected and then turn off the Calibrator. Now remove the Switch Matrix from the instrument and, using an ohmmeter, check the signal path by using the relay chart in the schematic section. Check individual relays by connecting an external power supply (a typical 9V battery works well) across the set coil to place the relay in the set position or the reset coil to place the relay in the reset position.

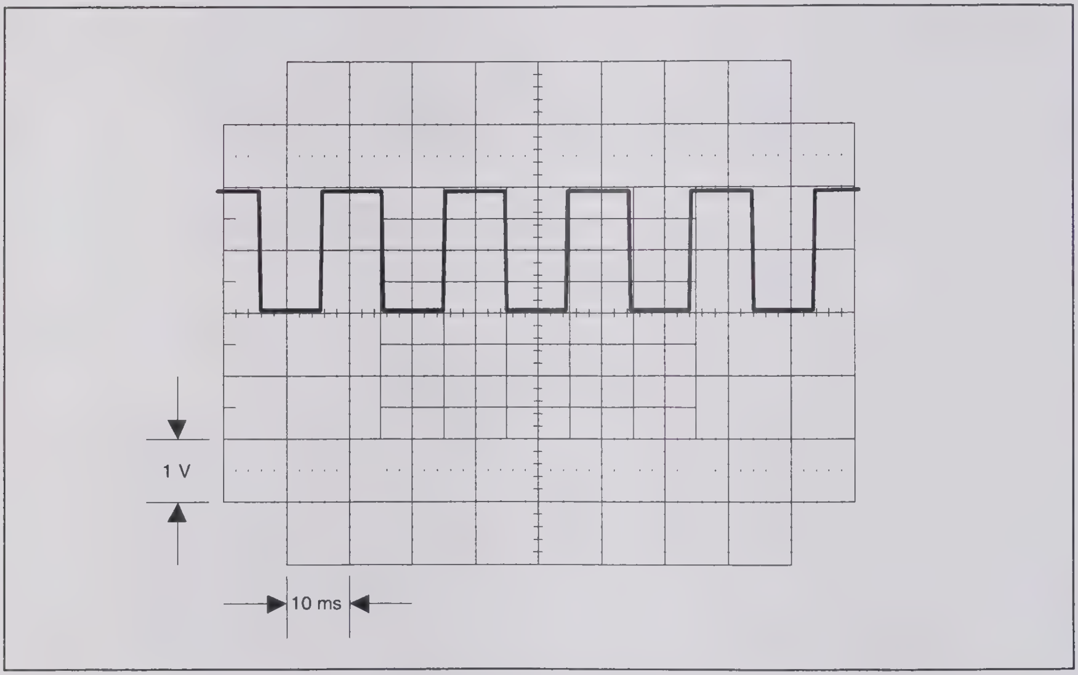

Figure 5-15. Waveform at TP16

2. Check the Motherboard relay RLY+V supply voltage. Set the Calibrator to 10V dc, operate. Connect an oscilloscope to RLY+V (common to TP9),which is at the cathode of CR2, and verify it is 4.5V ±0.5V. Now verify that each time the EX SNS key is pressed the voltage at RLY+V momentarily jumps to 7.5V ±1.2V. If a failure is detected, check the control line PC5, U17, Q1, Q2, and associated components.
3. Check the Motherboard relay control lines. Motherboard relays K1-K10 are controlled by U13 on the Switch Matrix assembly. If aMotherboard relay problem is suspected, verify U13 by using the relay chart in the Switch Matrix schematic section and checking for correct logic levels at its output.
4. Check the 2.2V Range Attenuator. Set the Calibrator to 2V dc, operate. Using a DMM measure the dc voltage at TP2 (common to TP8) and verify it is 2V ±6 mV.

Note

This 2V can be as much as ±0.12V if the DAC assembly is uncalibrated. If a failure is detected, check K1, K2, and the 5:1 divider part of the HR1 resistor network.

5. Check the 2.2V Range Amplifier. Set the Calibrator to 2V dc, operate. Using a DMM measure the dc voltage at TP4 (common to TP8) and verify it is 2V ±6 mV.

Note

This 2V can be as much as ±0.12V if the DAC assembly is uncalibrated. If a failure is detected, check the HR1 hybrid, U19, Q4, and associated components.

6. Check the mV Dividers. Set the Calibrator to 200 mV at 1 kHz, operate. Using a DMM measure the ac voltage at the cathode of CR6 (common to OUTPUT LO binding post) and verify it is 200 mV ±1%. Next, set the Calibrator to 20 mV at 1 kHz operate and again measure the ac voltage at the cathode of CR6. Verify it is 20 mV ±1%. If a failure is detected, check the resistive dividers in the HR1 resistor network and the associated relays.

Troubleshooting the Ohms Cal Assembly (A9) 5-10.

Proceed as follows to troubleshoot the Ohms Cal assembly (A9):

1. The Ohms Cal assembly contains the two-wire lead drop compensation circuit, calibration circuitry, the 1Ω, 1.9Ω, and short resistance values. All relays on the Ohms Cal assembly are latching type. These relays are put in the set or reset position and they remain in that position even after power has been removed. To troubleshoot the path through the relays simply set the Calibrator to the function in which problem is detected and then turn off the Calibrator. The relays remain in either the set or reset position. Check individual relays by connecting an external power supply (a typical 9V battery works well) across the set coil to place the relay in the set position or the reset coil to place the relay in the reset position. Remove the rear shield from the assembly and put it up on the extender card. Power up the Calibrator and continue as follows.
2. Check the 1Ω, 1.9Ω, and short. Connect a four-terminal ohmmeter(such as a Fluke Model 8505A) to the Ohms Cal assembly as follows. Connect 8505A IN HI to TP1, 8505A IN LO to TP 2, 8505A SENSE HI to TP5, 8505A SENSE LO to TP6. Set the Calibrator to 1Ω, operate, EXT SNS, and verify the ohmmeter reads 1Ω ±0.1%. If a failure is detected, check relays K4, K5, K6, and the four wire-wound resistors in R41. Set the Calibrator to 1.9Ω, operate, EXT SNS, and verify the ohmmeter reads 1.9Ω ±0.1%. If a failure is detected, check relays K4, K5, K30, and the two wire-wound resistors in R42. Set the Calibrator to 0Ω and verify the ohmmeter reads 0Ω ±0.1%. If a failure is detected, check relays K7 and K8.

Two-wire Compensation Circuit 5-11.

Proceed as follows to troubleshoot the two-wire compensation circuit:

1. Check the +8A and -8A power supply for the two-wire comp. circuit. Set the Calibrator to 100Ω, operate, and turn the two-wire comp on. Using a DMM measure the dc voltage at TP8 (common to TP7) and verify it is +8.2V ±5%. Next, measure the dc voltage at TP9 (common to TP7) and verify it is -8.2V ±5%. If these supply voltages are correct skip to step 2. If a failure is detected, first connect an oscilloscope to pin 16 of U6 with the scope common connected to pin 13 of U6. Set the oscilloscope to 5V/div at 10 us/div and verify it displays a waveform similar the Figure 5-16. If a failure is detected, check U6, Q5, Q6, Control line PB7, and associated components. If this signal is correct then check T1, CR1, CR2, CR9, CR10, VR1, VR2, and associated components.
2. Set the Calibrator to 100Ω, operate, INT SNS, and 2-Wire Comp ON. Connect a Fluke 8505A DMM, set to the 100Ω range, across the Calibrator OUTPUT HI and OUTPUT LO binding posts. The current from the DMM should be 10 mA. Using another DMM measure the dc voltage between pins 4 and 5 of U7 and verify it is less

than 4 µV. If a failure is detected check U7, U8, and associated components. Using a DMM measure the dc voltage across the 500Ω resistor in Z2 by connecting the DMM HI to TP18 and the DMM LO to TP17. Note this voltage which should be around 5.0V. Next, measure the voltage across the 1 kΩ resistor in Z2 by connecting the DMM HI to TP16 and the DMM LO to TP6. The voltage should be double and opposite polarity (gain = -2)of that previously measured (about -10V). If a failure is detected check U9, U10, and associated components.

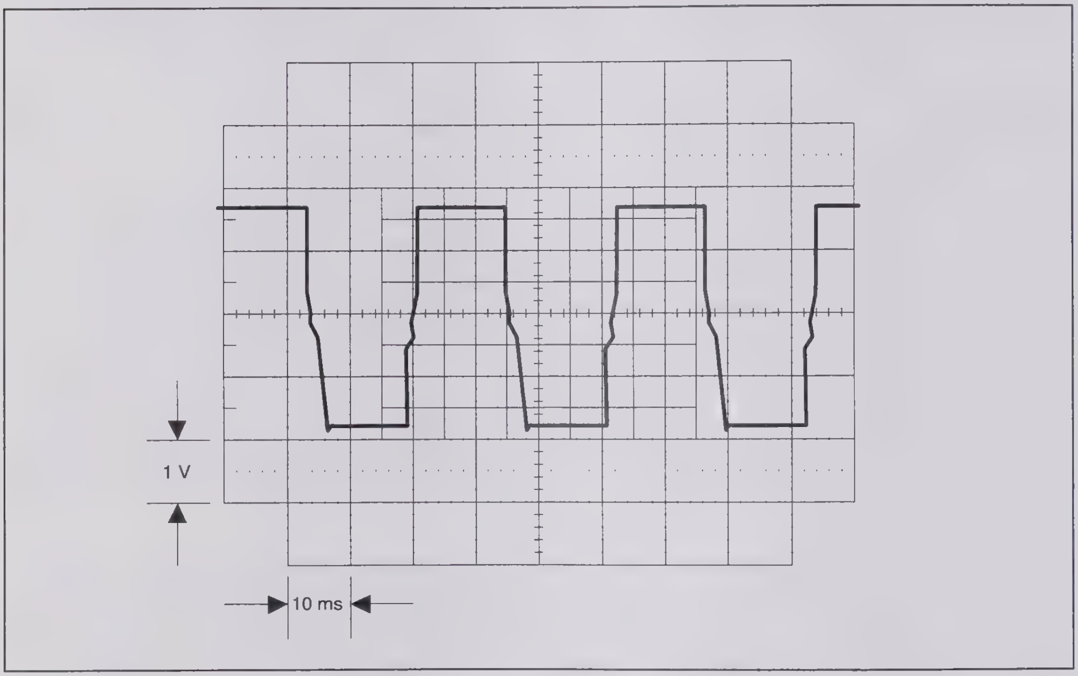

Figure 5-16. Waveform at Pin 13 of U6

Troubleshooting the Ohms Main Assembly (A10) 5-12.

Proceed as follows to troubleshoot the Ohms Main assembly (A10):

1. MΩ resistor in R1. All of the fixed values of resistance, available from the Calibrator, reside on the Ohms Main assembly except the 1.9Ω, 1.0Ω, and short. The fixed values of resistance from 10Ω to 100 MΩ are connected to the Calibrator output binding posts through relays on the Ohms Main, Ohms Cal, and Motherboard assemblies. The Ohms Main assembly is checked by verifying each fixed value of resistance and the relay path to INT OUT HI, INT SENSE HI, OHMS OUT LO, and OHMS SENSE LO. Place the Ohms Main assembly on the extender card, power up the Calibrator, and continue as follows.
2. Connect a four-terminal ohmmeter (such as the Fluke Model 8505A) to the Ohms Main assembly as follows. Connect 8505A IN HI to TP4, 8505A IN LO to TP3, 8505A SENSE HI to TP5, and 8505A SENSE LO to TP2. Set the Calibrator to 10Ω, operate, EXT SNS and verify the ohmmeter reads 10Ω ±0.07%. If a failure is detected, turn off the Calibrator and remove the Ohms Main assembly from the extender card. Use the schematic and the relay chart to check the connection from the test points to the 10Ω resistance.

Note

The connection from the test points to the resistance values is through latching type relays for all resistances except 10M, 19M, and 100 MΩ values. These relays are put in the set or reset position and remain in that position even after power has been removed. To troubleshoot the path through the relays, simply set the Calibrator to the function in which a problem is detected and then turn off the Calibrator. The relays remain in either the set or reset position. Check individual relays by connecting an external power supply (a typical 9V battery works well) across the set coil to place the relay in the set position or the reset coil to place the relay in the reset position.

3. Repeat step 2 for the resistances in Table 5-2 and verify they are within the specified tolerance.

Table 5-2. Ohms Main Resistance Tolerance

Resistance	Tolerance
19\Ω	+/-0.07%
100\Ω	+/-0.03%
190\Ω	+/-0.03%
1 k\Ω	+/-0.03%
1.9 k\Ω	+/-0.03%

4. Check the 100 MΩ resistance. Set up the ohmmeter for a two wire resistance measurement and connect IN HI to TP4 and IN LO to TP3. Set the Calibrator to 100 MΩ, operate, INT SNS, and verify the ohmmeter reads 100 MΩ ±5.0%. If a failure is detected, check relay K5 and90.

Troubleshooting the DAC Assembly (A11) 5-13.

Proceed as follows to troubleshoot the DAC assembly (A11):

1. Remove the front and back shields and place the DAC assembly on the extender card. Power up the Calibrator.
2. Check the 13V reference. Connect DMM to TP2 (common to TP3). The voltage should be between +13 and +14V and very stable. (Some drift may be seen while the assembly is warming up.) If the 13V reference is faulty, check the power supply voltages to the HR5 Reference Hybrid. If all the supplies are correct, the HR5 Reference Hybrid is probably at fault.
3. Check CH1 SHUNT. Connect an oscilloscope probe to TP6 (with common connected to TP3). Set the oscilloscope to 2V/div at 2 ms/div and verify it displays pulses as shown in Figure 5-17. If the displayed signal is incorrect, skip to Duty Cycle Control Circuit.
4. Check CH1 SERIES B. Connect an oscilloscope to TP4 (common to TP3).Set the oscilloscope to 10V/div at 2 ms/div and verify it displays pulses as shown in Figure 5-18. Next, set the Calibrator to 6.5V dc, operate. Verify the oscilloscope displays pulses with approximately 50% duty cycle as shown in Figure 5-19. If either of these displayed signals are incorrect, skip to Duty Cycle Control Circuit.

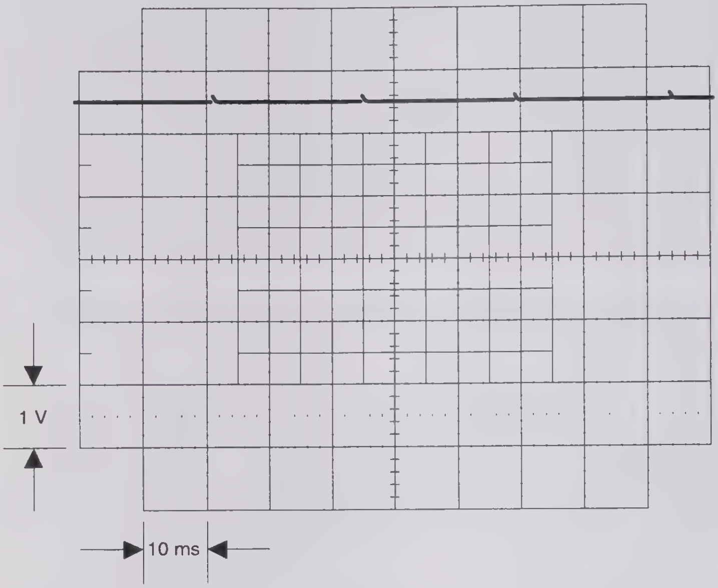

Figure 5-17. Waveform at TP6

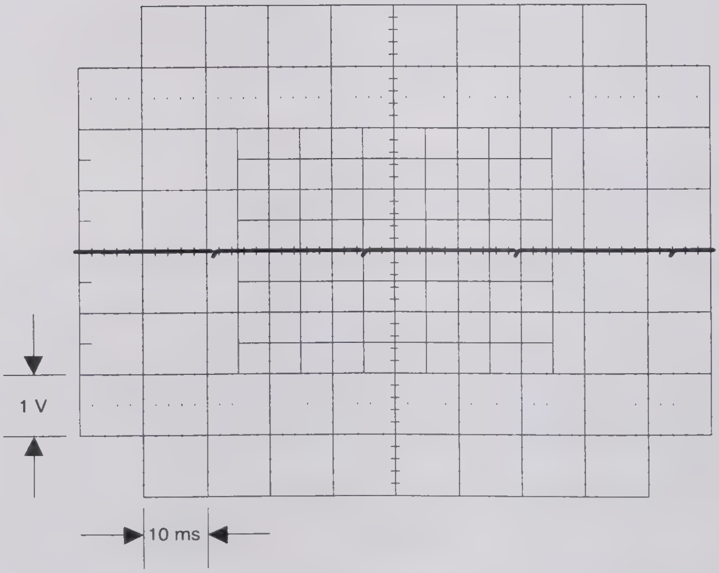

Figure 5-18. Waveform at TP4, Calibrator Set to 0V

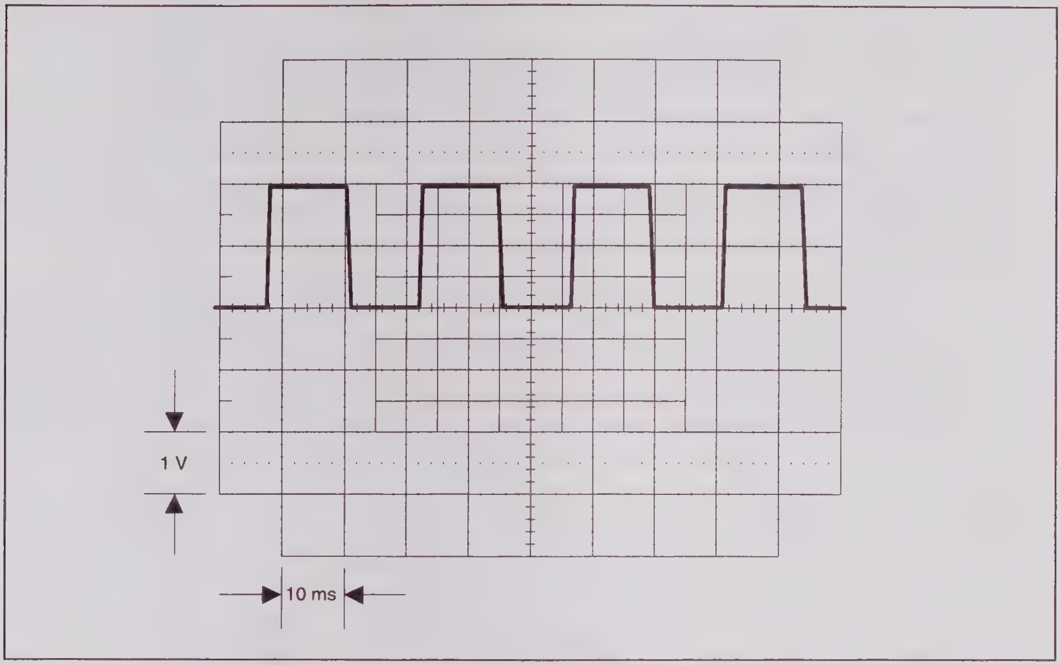

Figure 5-19. Waveform at TP4, Calibrator Set to 6.5V

5. Check CH2 FILTER INPUT. Connect an oscilloscope probe to TP7 (common to TP3). Set the Calibrator to 6.5V dc, operate. Set the oscilloscope to 2V/div at 2 ms/div. Verify the oscilloscope displays pulses similar to those shown in Figure 5-20.

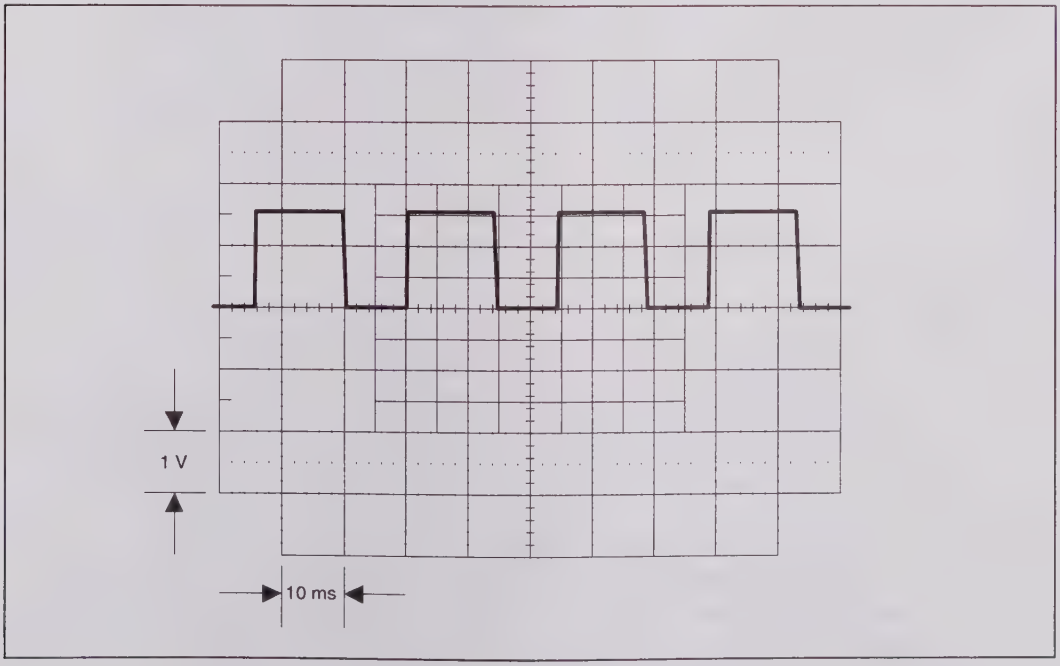

Figure 5-20. Waveform at TP7

Note

The duty cycle may differ from this figure. Using the Calibrator edit knob, vary the second LSD of the Calibrator output display and verify that the duty cycle of the signal at TP7 changes. If either of these displayed signals are incorrect, skip to Duty Cycle Control Circuit.

6. Check the SERIES LINEARITY CONTROL CIRCUIT. Using a DMM measure the voltage at U38 pin 6 (common to TP3). The voltage should be +23.0 to +26.4V. If this voltage is incorrect, check U38 and Z2.
7. Check the NEG. OFFSET CIRCUIT. Using a DMM measure the voltage at U2 pin 1 (common to TP3). The voltage should be -13 to -14V which is the reference voltage inverted. If this voltage is incorrect, check U2A and part of the HR6 resistor network.
8. Connect an oscilloscope to TP5 (common to TP3), and set the Calibrator to 6.5V dc, operate. Set the oscilloscope to 5V/div at 2 ms/div and verify the signal is similar to that shown in Figure 5-21. If this signal is incorrect, check Q4, Q5, Q6, and Q7.

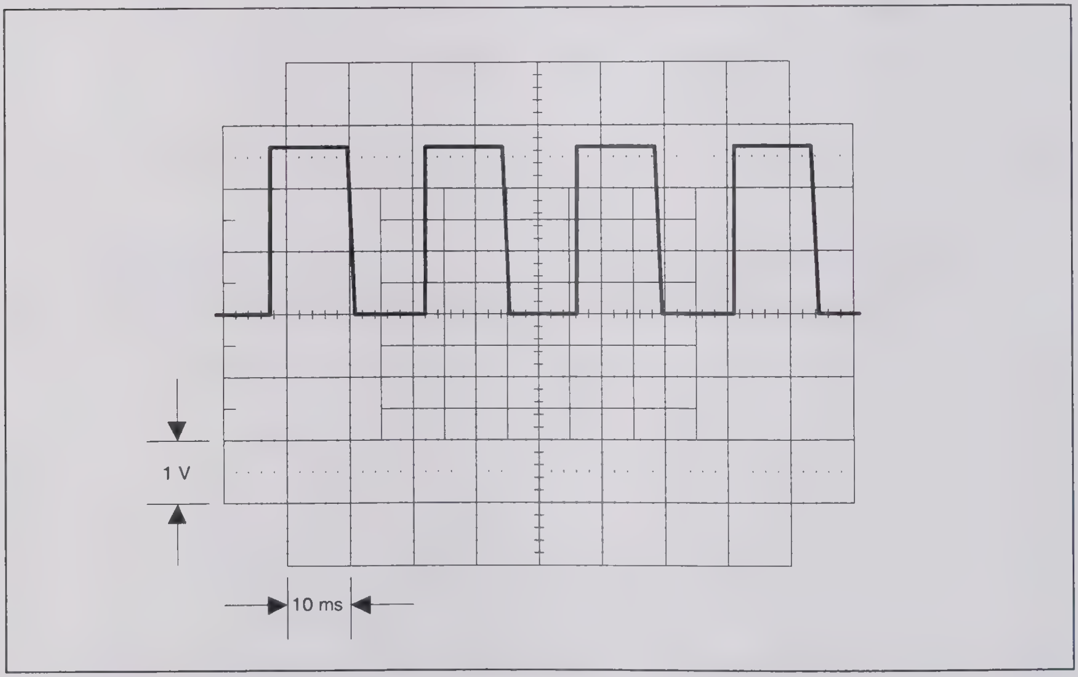

Figure 5-21. Waveform at TP5

9. Check the FILTER INPUT. Set the Calibrator to 6.5V dc, operate. Measure the voltage with a DMM at TP1 (common to TP3 on the main board) on the DAC Filter SIP assembly (A11A1). It should be a nominal +6.5V dc(±0.1V for an uncalibrated instrument), free of distortion, and stable. If a failure is detected, check the DAC Filter SIP assembly.
10. Check the DC AMP HYBRID. Set the Calibrator to 10V dc, operate. Measure the voltage with a DMM at pin 18 (common to TP3) of the HR6 DC AMP HYBRID. It should be a nominal +10V dc (±0.25V for an uncalibrated instrument), free of distortion, and stable. If a failure is detected, check the HR6 Hybrid assembly and its heater control circuit.

11. Check the OUTPUT BUFFER circuit. Set the Calibrator to 10V dc, operate. Measure the voltage with a DMM at L10 (common to TP3). It should be a nominal +10V dc (±0.25V for an uncalibrated instrument), free of distortion, and stable. If a failure is detected, check U5 and its associated components.
12. Check the DAC OUTPUT SWITCHING. Set the Calibrator to 10V dc, operate. Measure the DAC output voltage with a DMM a TP8 (common to TP12).It should be a nominal +10V dc (±0.25V for an uncalibrated instrument). Set the Calibrator to -10V dc, operate. Again check the voltage at TP8 (common to TP12). It should be a nominal -10V dc(±0.25V for an uncalibrated instrument). If either of these voltages are incorrect, check the output switching relays K1, K2, K8, and their drive circuitry.
13. Check the RANGE SELECT control line. Set the Calibrator to 10V dc, operate. Using a DMM measure the RANGE SELECT control line at U37 pin 7 (common to TP3). It should be -16 to -19V dc. Set the Calibrator to 20V operate and again measure the RANGE SELECT control line for +4.0V to +11V. If either of these measurements are incorrect, check U37, U8B, U8C, and their associated components.
14. Check the DAC 20V Range. Set the Calibrator to 20V dc, operate. Using a DMM measure the DAC output voltage at TP8 (common to TP3). It should be a nominal 20V dc (±0.5V for an uncalibrated instrument). If a failure is detected, check Q14, Q15, Q18, Q19, Q20, Q21, and their associated components.
15. Check the SHUNT LINEARITY CONTROL CIRCUIT. Set the Calibrator to 10V dc, operate. Measure the voltage with a DMM at U2 pin 7 (common to TP3).It should be a nominal -10V dc (±0.35V for an uncalibrated instrument and ±0.1V for a calibrated instrument). Set the Calibrator to 20V dc, operate, and again measure the voltage at U2B pin 7. It should still be the nominal -10V dc within the same tolerance. If either of these voltages are incorrect, check U2B, Q22, and the associated 80 kΩ resistors in the HR6 Hybrid assembly.
16. Check the SENSE HI CURRENT CANCELLATION CIRCUIT. Set the Calibrator to 10V dc, operate. Measure the voltage with a DMM at TP8 (common to TP3) and Note the reading. Next, measure the output high binding post of the Calibrator (common to TP3). It should be the same as the Noted reading ±10 ppm. If a failure is detected, check U1A and associated components in the Sense Hi Current Cancellation Circuit.

Duty-cycle Control Circuit *5-14.*

Proceed as follows to troubleshoot the duty-cycle control circuit:

1. Check the 8 MHz clock for U6. Connect an oscilloscope to U6 pin 10(common to TP1). Set the oscilloscope for 2V/div at 100 ns/div and verify the display shows an 8 MHz clock similar to that shown in Figure 5-22. If a failure is detected, check U7 and its associated components. The input signal (CLK and CLK*) to U7 is a low-level(400 mV p-p) 8 MHz clock generated by the Regulator/Guard Crossing assembly.
2. Check OUT1 from U6. Connect an oscilloscope to U6 pin 16 (common to TP1). Set the Calibrator to 6.5V dc, operate, and set the oscilloscope to 2V/div at 2 ms/div. The oscilloscope should display a TTL-level square wave with approximately a 50% duty cycle. If a failure is detected, check U6 and all its control lines.
3. Check OUT2 from U6. Connect an oscilloscope to U6 pin 20 (common to TP1). Set the Calibrator to 6.5V dc, operate, and the oscilloscope to 2V/div at 2 ms/div. The oscilloscope should display a TTL level square wave. If a failure is detected, U6 is probably at fault.

4. Check CH1 FLOATING. Connect an oscilloscope to U13 pin 6 (common to TP1). Set the Calibrator to 6.5V dc, operate, and the oscilloscope to 2V/div at 2 ms/div. The oscilloscope should display a TTL level signal similar to Figure 5-23. If a failure is detected, check U13 and its associated components.
5. Check the Clock to U14. Connect an oscilloscope to U10 pin 4 (common= TP3) and set it for 2V/div at 100 ns/div. Verify it displays a 8 MHz clock similar to Figure 5-24. If a failure is detected, check U10 and its associated components.
6. Check the Watchdog Clock. Connect an oscilloscope to U14 pin 8(common to TP3) and verify it displays a TTL level 4 MHz clock. If a failure is detected, check U14.
7. Check the Watchdog Timer. Connect an oscilloscope to U15 pin 13(common to TP3) and verify it displays a constant logic high. If a failure is detected, check U15 and associated components.
8. Check the Q1 and Q1* output of U14. Connect an oscilloscope to U14 pin 5 (common to TP3). Set the Calibrator to 6.5V dc, operate, and set the oscilloscope to 2V/div at 2 ms/div. The oscilloscope should display a TTL-level square wave with approximately a 50% duty cycle. Connect the oscilloscope to pin 6 of U14 and verify it to be the compliment signal. If either signal is incorrect, U14 is probably at fault.

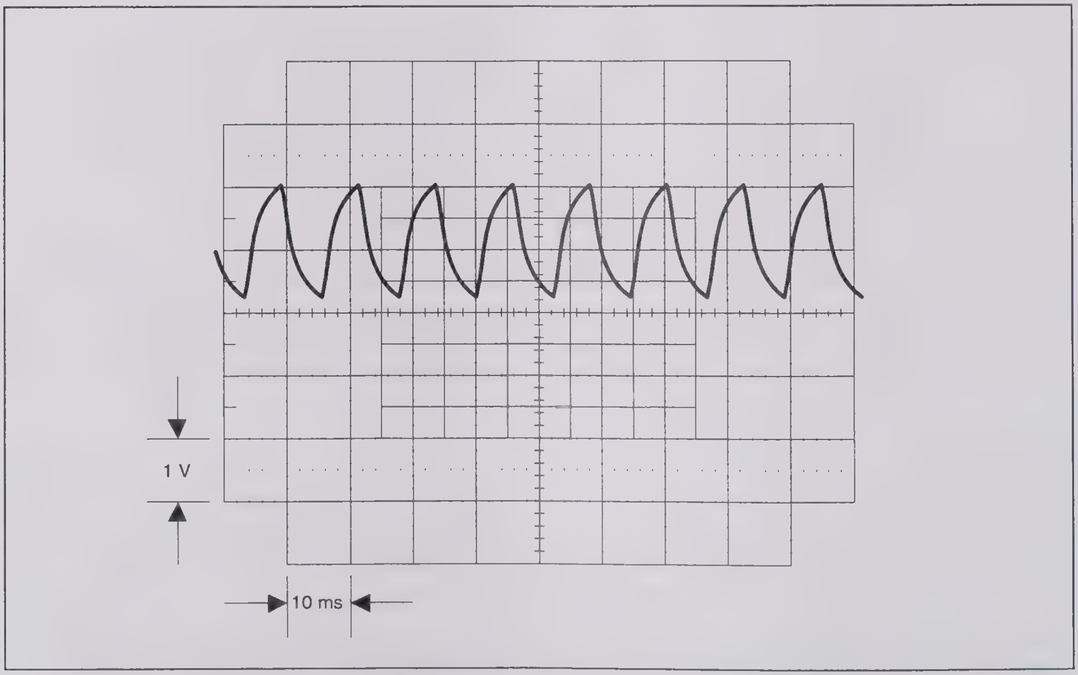

Figure 5-22. Waveform at Pin 10 of U6

9. Check CH1 SHUNT. Connect an oscilloscope to TP6 (common to TP3). Set the Calibrator to 6.5V dc, operate, and set the oscilloscope to 2V/div at 2 ms/div. The oscilloscope should display a signal similar to Figure 5-25. If a failure is detected, check Q35 and its associated components.

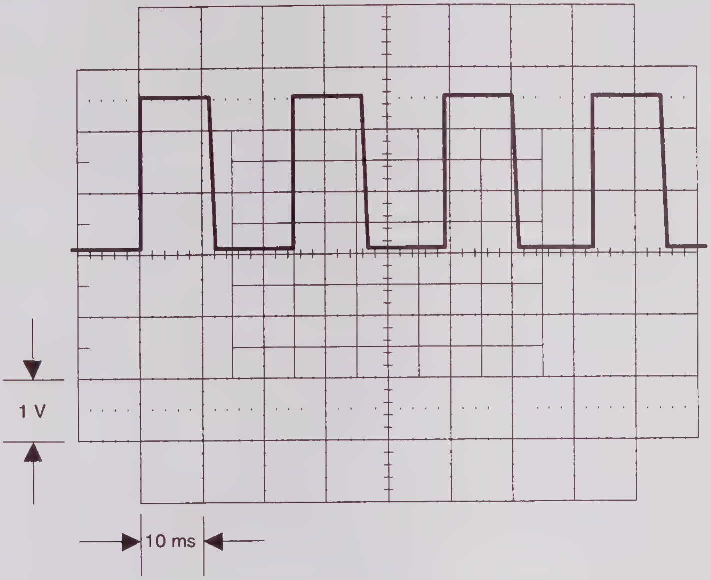

Figure 5-23. Waveform at Pin 6 of U13

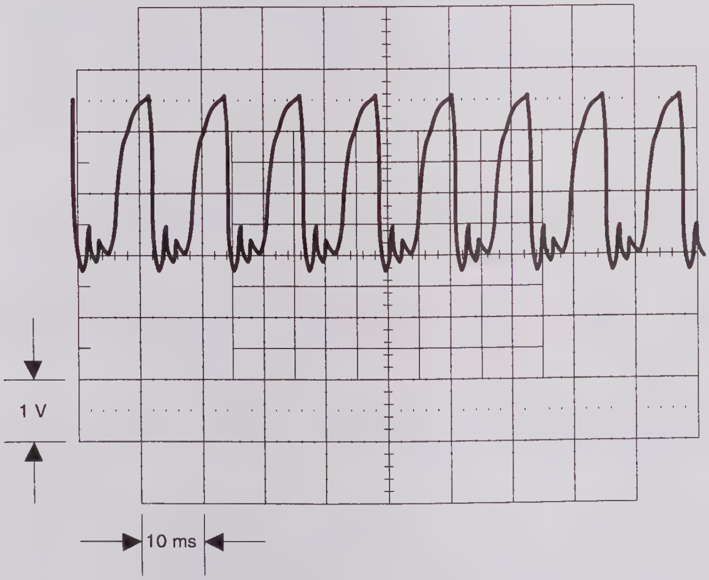

Figure 5-24. Waveform at Pin 4 of U10

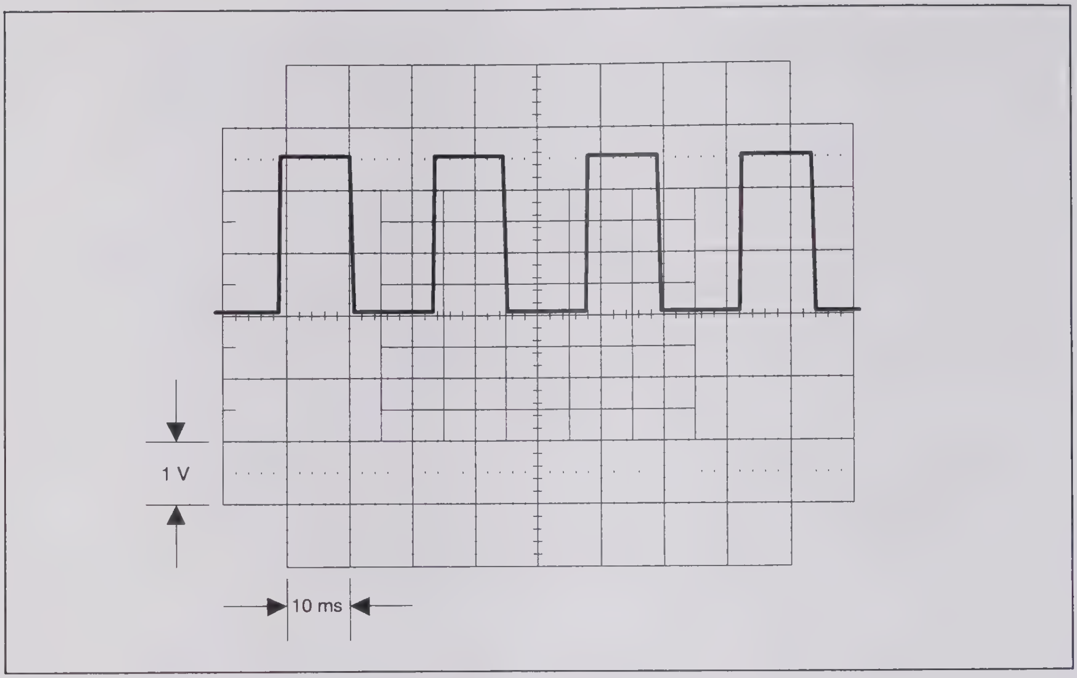

Figure 5-25. Waveform at TP6

10. Check CH1 SERIES B. Connect an oscilloscope to TP4 (common to TP3).Set the Calibrator to 6.5V dc, operate, and the oscilloscope to 10V/div at 2 ms/div. The oscilloscope should display a signal similar to previously shown Figure 5-19. If a failure is detected, check Q33, Q34, and their associated components.
11. Check CH2 FLOATING. Connect an oscilloscope to U12 pin 7 (common to TP3) and set it to 10V/div at 2 ms/div. Verify it displays a signal similar to Figure 5-26.

Note

The duty cycle may differ from Figure 5-26. At this time just verify the amplitude and a sharp rise and fall time. If a failure is detected, check U12 and its associated components.

12. Check 3V reference. Using a DMM measure the voltage at U11 pin 3(common to TP3) for a nominal 3V dc. If this voltage is incorrect check U1B and the associated resistors on the HR5 Hybrid assembly.
13. Check CH2 FILTER INPUT. Connect an oscilloscope to TP7 (common to TP3) and set it to 2V/div at 2 ms/div. Verify it displays a signal similar to the previously shown Figure 5-20.

Note

The duty cycle may differ from Figure 5-20. If a failure is detected, check U11, Q30, Q31, Q32, and their associated components.

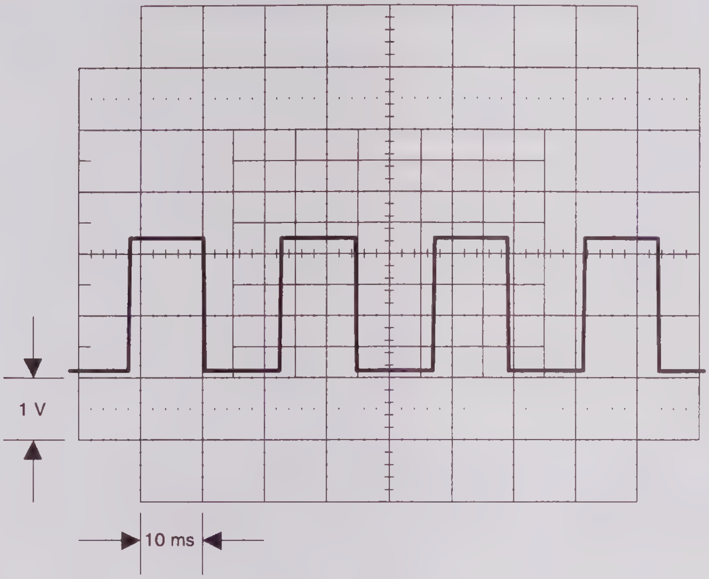

Figure 5-26. Waveform at Pin 7 of U12

ADC Circuit *5-15.*

Proceed as follows to troubleshoot the ADC circuit:

1. Check the ADC INPUT select circuit. Set the Calibrator to 10V dc, operate. Verify that the voltage at U23 pin 7 (common to TP12) is 0.45V±7%. If this voltage is incorrect, check U23 and its control lines. At this time DAC HI DIAG is divided by R79 and R84 (0.45V)and selected by control line DAC DIAG SEL.
2. Check the ADC INPUT. Set the Calibrator to 10V dc, operate. Verify that the voltage at U25 pin 22 (common to TP12) is 0.45V±7%. If this voltage is incorrect, check U24 and its associated components.
3. Check the buffered DAC LO DIAG. Set the Calibrator to standby. Verify that the voltage at U22 pin 6 (common to TP1) is 0V±11 mV. If this voltage is incorrect, check U22 and associated components.
4. Check the ADC +7.5V supply. Set the Calibrator to standby. Verify that the voltage at U25 pin 16 (common to TP1) is 7.5±0.5V. If this voltage is incorrect, check VR27 and R77.
5. Check the ADC -8.2V supply. Set the Calibrator to standby. Verify that the voltage at U25 pin 17 (common to TP1) is -8.2±0.5V. If this voltage is incorrect, check VR28 and R94.
6. Check the BUFFERED ADC COM. Set the Calibrator to standby. Verify that the voltage at U26 pin 7 (common to TP12) is 0V±600 mV. If this voltage is incorrect, check U20B, U26A, and associated components.
7. Check the ADC -6.4V Reference. Verify that the voltage at the anode of VR29 (common to TP12) is -6.4±0.2V. If this voltage is incorrect, check VR29, VR30, U20B, U26A, and associated components.

8. Check the ADC +6.4V Reference. Verify that the voltage at U27 pin 1(common to TP12) is 6.4±0.2V. If this voltage is incorrect, check U27B and associated components.
9. Check the ADC SAMPLE/HOLD +BOOTSTRAP supply. Set the Calibrator to standby. Verify that the voltage at U29 pin 7 (common to TP12) is between 5.4 and 8.2V. If this voltage is incorrect, check U29, Q56, Q57, VR31-VR34, and associated components.
10. Check the ADC SAMPLE/HOLD -BOOTSTRAP supply. Set the Calibrator to standby. Verify that the voltage at U29 pin 4 (common to TP12) is between -5.4 and -8.2V. If this voltage is incorrect, check U29, Q56, Q57, VR31- VR34, and associated components.
11. Check the -INPUT of the ADC AMP. Set the Calibrator to 2V at 1 kHz, operate, and measure the voltage at TP10 (common to TP12). The voltage should be a nominal 6.3V dc which is the output of the DAC. If this voltage is incorrect, check relay K5 and its drive circuit.
12. Check the +INPUT of the ADC AMP. Set the Calibrator to 2V at 1 kHz, operate, and measure the voltage at TP9 (common to TP12). The voltage should be a nominal 6.3V dc which is the voltage on the RCL line. If this voltage is incorrect, check relays K6, K7, and their drive circuit.
13. Check ADC AMP gain. Set the Calibrator to 2V at 1 kHz, operate. Measure the voltage at TP9 (+INPUT) with common to TP10 (-INPUT) and Note the reading. Next, measure the voltage at TP11 with common to TP12 and verify that it is 11 times greater (±15 mV) than the previous Noted reading. If this voltage is incorrect, check U19A, U19B, and their associated components.
14. Check the ADC INPUT select. Set the Calibrator to 2V at 1 kHz, operate, and measure the voltage at U23 pin 7 (common to TP12). It should be the same as the voltage measured at TP11 in the previous step. If it is not, check U23 and the control line ADC AMP OUT SEL.

Buffered Reference Sip Assembly (A11A2): *5-16.*

Proceed as follows to troubleshoot the Buffered Reference SIP Assembly (A11A2). Set the Calibrator to the power-up default state for these tests:

1. Check the buffered 6.5V reference. Measure the voltage at TP1 on the Buffered Reference SIP assembly (common to TP1 on the main board).This voltage should be between 6.5 and 7.0V dc and very stable. If this voltage is incorrect, check U1A, U2A, Q3, and Q4 on the Buffered Reference SIP assembly (A11-A2).
2. Check the buffered 13V reference. Measure the voltage at TP2 on the Buffered Reference SIP assembly (common to TP1 on the main). This voltage should be between 13 and 14V dc and very stable. If this voltage is incorrect, check U1B, U2B, Q10, and Q11 on the Buffered Reference SIP assembly (A11-A2).

Troubleshooting the Oscillator Control Assembly (A12) 5-17.

The first part of this troubleshooting procedure (steps 1 through 7) checks the averaging converter. The second part (steps 8 through 10) checks the AC/DC transfer circuit.

Note

During normal operation of the Calibrator, internal software monitors the output and makes corrections or trips the instrument to standby. This internal monitoring can cause problems when attempting to troubleshoot the Oscillator Control assembly. Defeat the monitoring by connecting a jumper from TP9 to TP10 on the DAC assembly and another jumper connecting SDL (P501 pin 11A/11C) to SCOM (P502pin 32A/32C) on the Oscillator Control assembly.

After defeating the monitoring circuit, remove the rear shield and place the Oscillator Control assembly on the extender card. Power up the Calibrator and proceed as follows to troubleshoot the Oscillator Control assembly (A12):

1. Check inputs to the Oscillator Control assembly. Set the Calibrator to 1.0V at 1 kHz, operate. On this Oscillator Control assembly measure the DAC assembly output voltage at TP3 (common to TP2) for 3.16V dc ±50 mV. Also measure OSC SENSE HI at TP1 for a nominal 1.0V ac ±50 mV. If these voltages are incorrect, check the input switching relay K1 and its drive circuitry.
2. Check the CURRENT CANCELLATION CIRCUITS. Set the Calibrator to 1.0V at 1 kHz, operate. Measure the ac voltage at TP1 (common to TP2) and Note the reading. Move the DMM test leads to the output of the Calibrator. The measured ac voltage should be the same as Noted ±10 ppm. If a failure is detected, check the CURRENT CANCELLATION CIRCUITS as outlined on the schematic.
3. Check the BUFFER AMP circuit. Set the Calibrator to 1.0V at 1 kHz, operate, and measure the BUFFER AMP output at TP4 (common to TP2). It should be the same voltage as on TP1 ±1%, with <<50 mV of offset. Change the Calibrator output to 10.0V and again measure the BUFFER AMP output. The voltage should remain the same ±1%. If these voltages are incorrect, check the input attenuator (Z2 and K3)and the BUFFER AMP (U3 and associated components).
4. Check the RECTIFYING AMP circuit. Connect an oscilloscope to the anode of CR4 (common to TP2). Set the oscilloscope to 2V/div. and 200 us/div. The oscilloscope should display a signal as in Figure 5-27. If the signal is incorrect, check U5, U7, Q3, Q4, CR4, CR5, and associated components in the RECTIFYING AMP circuit.
5. Check the 15 BIT DAC circuit. Set the Calibrator to 1.0V at 1 kHz, operate. Connect a DMM to U26 pin 6 (common to TP2) which is 14 BITDAC OUT. It should be stable dc voltage between 0 and -3.16V. If this voltage is incorrect, check U10, U26, Q19, and associated components in the 15 BIT DAC circuit.
6. Check the ERROR INTEGRATOR output. Set the Calibrator to 1.0V at 1 kHz, operate. Connect an oscilloscope to U11 pin 6 (common to TP2) which is ERROR INT. OUT. Set the oscilloscope to 500 mV/div and 200us/div. The oscilloscope should display a ripple similar to Figure 5-28. The dc level of this signal can be between -5V and +5V. If an error is detected, check U11 and associated components.
7. Check the OSC CONT signal. Set the Calibrator to 1.0V at 1 kHz, operate. Connect the oscilloscope to TP5 (common to TP2). OSC CONT should be a dc voltage between +5 and -5V, free of distortion. If this voltage is incorrect, check U8, U9B, and associated components in the 3 POLE FILTER circuit and buffer amp U9A.

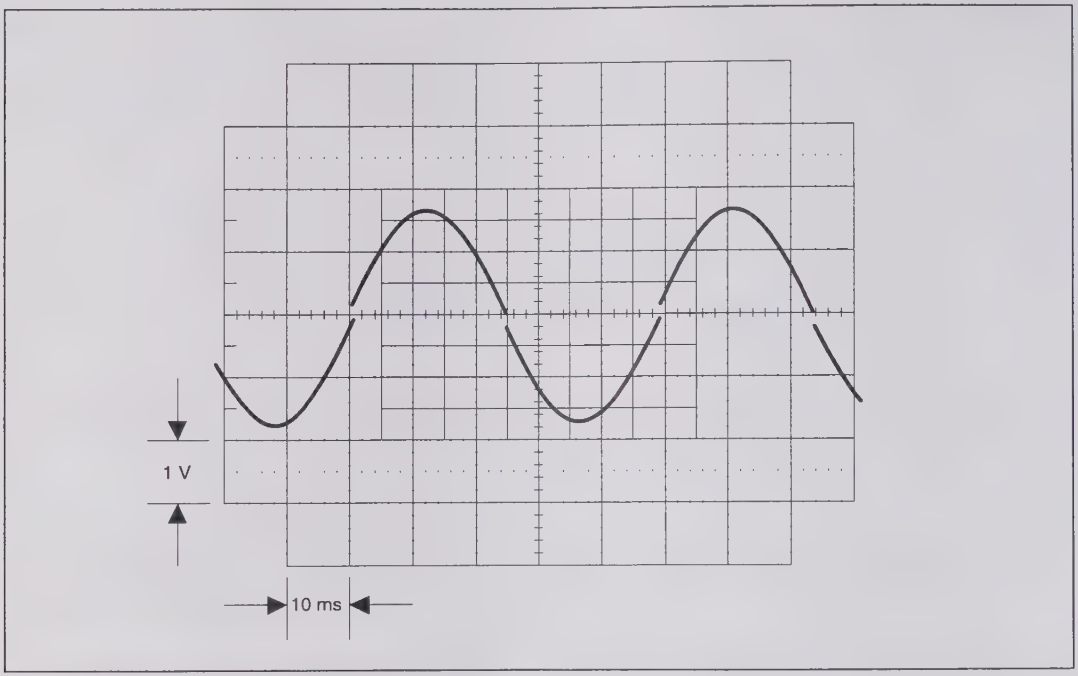

Figure 5-27. Waveform at Anode of CR4

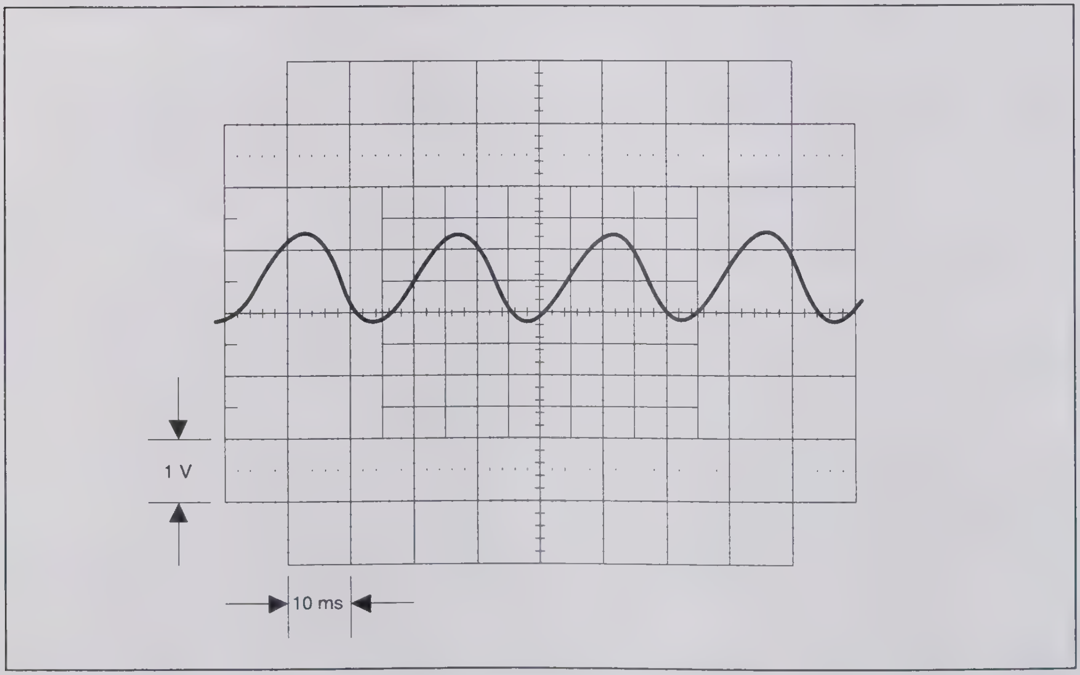

Figure 5-28. Waveform at Pin 6 of U11

8. Check the DC SENSE BUFFER and the AC SENSE BUFFER. Set the Calibrator to 1.0V at 1 kHz, operate. Connect an oscilloscope to TP6 (common to TP2) which is the input to the AC/DC sensor. The oscilloscope display should be switching between Figure 5-29, which is the output of the DC SENSE BUFFER circuit and

Figure 5-30, which is the output of the AC SENSE BUFFER circuit. If either of these signals is incorrect, check the appropriate SENSE BUFFER circuit as outlined on the schematic. If these voltages are correct, set the Calibrator to 10.0V at 1 kHz, operate, and verify the ac amplitude from the AC SENSE BUFFER remains the same. If a failure is detected, check relay K4 and resistor Z3 in the AC SENSE BUFFER circuit.

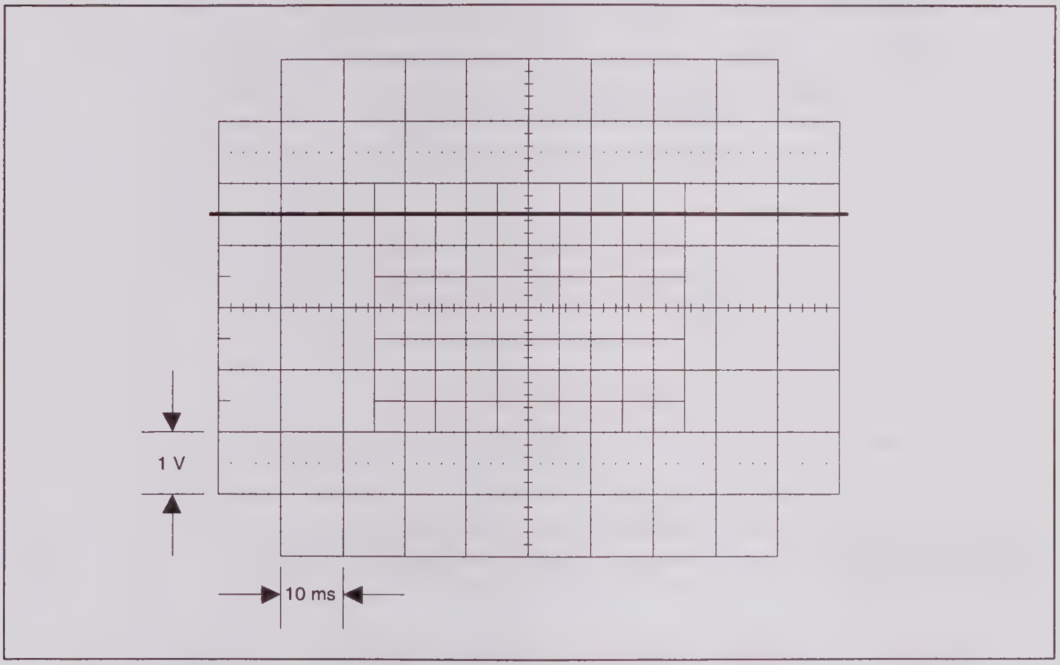

Figure 5-29. DC Sense Buffer Waveform TP6

Note

Before proceeding remove the jumper connecting SDL to SCOM on this Oscillator Control assembly and the jumper connecting TP9 to TP10 on the DAC assembly.

9. Check the AC/DC THERMAL SENSOR & SQUARE ROOT AMP. Set the Calibrator to 1.0V at 1 kHz, operate. Connect a DMM to TP7 (common to TP2) which is the output of the Fluke RMS Sensor. The DMM should read 3.16V dc ±160 mV. If this voltage is incorrect, check U14, U15, U17, and associated components.
10. Check the RCL ANALOG SWITCHING circuit. Set the Calibrator to 1.0V at 1 kHz, operate. Connect a DMM to TP8 (common to TP2) which is the RCL line. The DMM should read the same voltage at TP7 in the previous step. If this voltage is incorrect, check U19A, K6, and their drive circuitry. Set the Calibrator to 5V at 1 kHz, operate. The DMM connect to TP8 should read 1.58V ±160 mV. If this voltage is incorrect, check U31, U19B, K7, and their appropriate drive circuit.

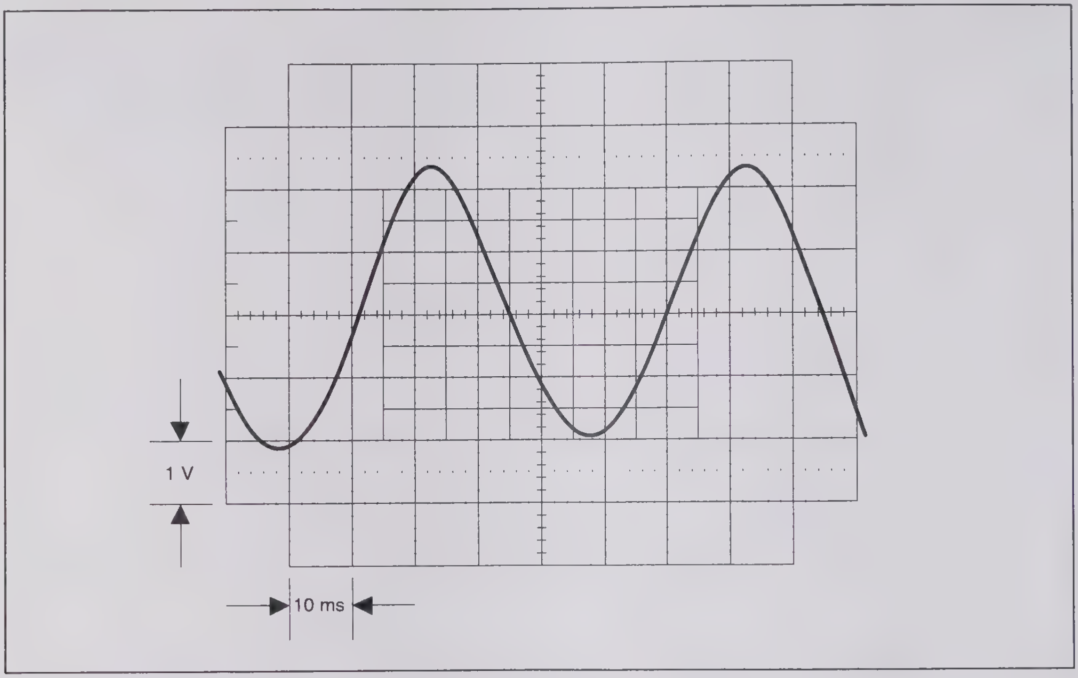

Figure 5-30. AC Sense Buffer Waveform at TP6

Troubleshooting the Oscillator Output Assembly (A13) *5-18.*

Note

During normal Calibrator operation, internal software monitors the output and makes corrections or trips the instrument to standby. This internal monitoring can cause problems when attempting to troubleshoot the Oscillator Output assembly. Defeat the monitoring by connecting a jumper from TP9 to TP10 on the DAC assembly and another jumper connecting SDL (P511 pin 11A/11C) to SCOM (TP1) on the Oscillator Output assembly.

After defeating software monitoring, Remove the front air duct and rear shield from the Oscillator Output assembly. Place the assembly on the extender card, and proceed as follows to troubleshoot the Oscillator Output Assembly (A13):

1. Turn on the Calibrator.
2. Check for oscillation at INT OSC OUT. Connect an oscilloscope probe to TP3 (common to TP1). A 100 Hz sine wave at 5.12V rms ±0.25V should be present. If no oscillation is present proceed with step 3; otherwise skip to step 4.
3. Unsolder and lift up one end of feedback resistor R6. Jumper the input to the SUMMING AMPLIFIER (the node of R1, R6, and U3 pin 5) to the +5S supply. All four amplifiers in this oscillator section are inverting amplifiers. With a positive voltage at the input, check for the following:
    - TP5: negative voltage
    - TP4: positive voltage
    - TP3: negative voltage
    - Pin 6 of U8: negative voltage

4. Next, jumper the input of the SUMMING AMPLIFIER to the -5S supply and check the following:
    - TP5: positive voltage
    - TP4: negative voltage
    - TP3: positive voltage
    - Pin 6 of U8: positive voltage
5. Repair any amplifier circuits which are not properly inverting. Reinstall feedback resistor R6. If the 100 Hz oscillation is still not present, check rectifying diodes CR1-CR4 and the summing resistors in Z6. The output of Z6 is summed with the -12V reference by R42 and R43. Check the ERROR INTEGRATOR circuit by making sure opamp U18 is inverting. If it is not, check U18 and its associated circuitry. If U18 is inverting properly, the problem is probably due to the MULTIPLIER U16 or its associated components.
6. Check INT OSC OUT for correct oscillation at each frequency range. Connect an oscilloscope to TP3 (common to TP1). Set the Calibrator for 2V at 100 Hz, 1 kHz, 10 kHz, 100 kHz, and 1 MHz. If any of the frequency ranges are bad (i.e., no oscillation or oscillation at the wrong frequency range or wrong voltage) check relays K1, K2, K3, their associated drive circuits, and the amplifier feedback capacitors that these relays select.
7. Check INT OSC OUT for correct frequency oscillation within a frequency range. Connect a frequency counter to TP3 (common to TP1). Set the Calibrator for 2V at 5 kHz, operate. Check each frequency digitusing the edit knob. If a failure is detected, check the FREQ DATA bus D1-D7 (D0 is only used during external phase lock) by editing the frequency and seeing that each bit toggles between +5V and ground. If each bit of the FREQ DATA bus is toggling properly the problem is probably due to resistive DACs U5 and/or U7. If a failure with the FREQ DATA bus is detected, U32 is probably at fault.
8. Check the 2.2V range output of the Oscillator. Set the Calibrator for 2V at 1 kHz, operate. Measure the output at TP2 (common to TP1) for an undistorted sine wave of 2V (±50 mV) at 1 kHz with no offset. If the output is incorrect perform the resistor check as follows:
    a. Move switch S1 to the test position (to the left).
    b. Measure the voltage drop across R87. It should be 1V ±20%. If this voltage is incorrect, the 10 mA current source on the Oscillator Wideband SMD (A13A1) assembly if probably at fault.
    c. Verify that the voltage at TP2 is about +3.2V ±0.3V. If this voltage is incorrect, the output stage circuit is probably at fault. If this voltage is correct the Oscillator Wideband SMD (A13A1) assembly is probably at fault.
    d. Return the switch to the operate position (move to the right).
9. Check the amplitude control within the 2.2V range. Set the Calibrator for 1V at 1 kHz, operate. Edit the amplitude digits and verify the output changes accordingly. If a problem is detected, edit the output digits again and check each bit (A0-A7) of the AMPL DATA bus to ensure they toggle between +5V and ground. If they do not, U12 is probably faulty. If the AMPL DATA bus is operating, the resistive DAC U11 is probably at fault.
10. Check the 22V range output of the Oscillator. Set the Calibrator for 20V at 1 kHz, operate. Check the output at TP2 (common to TP1) for an undistorted sine wave of 20±0.5V at 1 kHz. If the output is incorrect, check range setting relay K4 and its associated resistor.

11. Check the Phase Lock circuit. Connect a frequency counter to the Calibrator output. Set the Calibrator to 2V at 1 kHz, operate, and check the frequency accuracy to be within 0.01% of the nominal. If the frequency is out of tolerance, proceed as follows:
    a. Check the ZERO CROSSING DETECTORS by connecting an oscilloscope to U23 pins 7 and 12 (common = TP1). Ensure they convert the sine wave inputs to square wave outputs.
    b. Check the PHASE DETECTOR outputs by connecting an oscilloscope to U22 pins 5 and 7. With the circuit not phased locked one of these points should be pulsing. If not, check U22 and associated components.
    c. Check the LOOP FILTER & CHARGE PUMP circuit by connecting an oscilloscope to TP7. With the circuit not phase-locked, TP7 should be either +13V or -13V. If this voltage is incorrect, check U17, U31A, and associated components. If this voltage is correct, the problem is probably U19 and/or U15 in the MULTIPLIER circuit.
12. Check the PHASE SHIFTER circuit. Using a dual-channel oscilloscope connect one channel to the TP2 (oscillator output), and the other channel to TP8 (P SHIFT HI). Set the Calibrator to 2V at 1 kHz, operate. On the front panel select the "Phase Ctrls Menu" softkey, followed by the "Phase Shift" softkey to turn the phase shift function on. The oscilloscope should show two sine waves that are in phase. By pressing the "Adjust Phase Shift" softkey and then either the softkeys or rotating the edit knob the phase between these two signal should shift over the entire 360 degree range. If a failure is detected, first check the control lines for this circuit. On U27 check pin 6 (INHPH) for a logic low, pin 9 (BPH) and pin 10 (APH) should toggle between a logic high and low depending on the degrees of phase shift selected. If these control lines are incorrect, check U33. If the control lines are correct check U27, U28, and the associated components in the PHASE SHIFTER circuit.

Troubleshooting the High Voltage Control Assembly (A14) *5-19.*

1. Remove the rear shield from the High Voltage Control assembly and place it on the extender card. All measurements will be referenced to PACOM (TP6) unless Noted otherwise. Power up the Calibrator and proceed as follows.

Warning

high voltages are exposed when troubleshooting the high voltage control assembly.

2. Measure the voltage at TP4 with a DMM and verify it is between +0.1 and +0.3V. If a failure is detected, check U2C, U6, and associated components. Next, power down the Calibrator and connect an oscilloscope, set for 20V/div and 500 us/div, to TP3. At power up of the Calibrator the oscilloscope should displays a 1 kHz square wave which ramps up to the level shown in Figure 5-31, remains there for approximately 1 second, and goes to a 0V. If a failure is detected, skip to the Magnitude Control circuit troubleshooting in this section.

Note

The following step 3 checks the operation of the High Voltage Control assembly in the 1100V AC Range. If may be useful to refer to Figure 2-25 in the Theory of Operation Section.

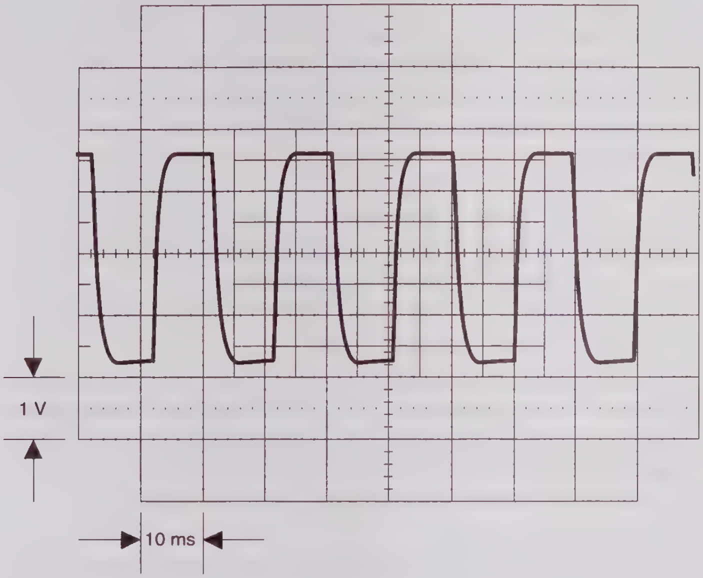

Figure 5-31. Waveform at TP3

3. Check the High Voltage Control in the 1100V ac range. Set the Calibrator to 220V at 110 Hz and 130 Hz, operate. At both output frequencies measure with a DMM the ac voltage at pin 1A or 1C of connector P611 and verify it reads 220±0.2V. In this range the High Voltage Control assembly and Power Amplifier assembly work together to form an overall amplifier with a gain of -100. If a failure is detected, check T1, K1, K14, K15, K16, K9, K6, K5, K12, and K3.

Note

Steps 4 through 7 check the operation of the High Voltage Control assembly in the 1100V DC Range. If may be useful to refer to Figure 2-26 in the Theory of Operation Section.

4. Check the -SP C and +SP C from the High Voltage/High Current assembly. Set the Calibrator to 0V standby. Using a DMM, measure the dc voltage at the cathode of VR4 (-SP C) and verify it is between +13.2 and +14.2V. Next, measure the anode of VR5 (+SP C) and verify it is-0.1V to -0.3V. If a failure is detected, the HV DC Output Series Pass & Current Limit Circuit on the High Voltage/High Current (A15)assembly may be at fault.
5. Check the output from the Magnitude Control circuit. Set the Calibrator to +220V dc, operate. Connect an oscilloscope to TP3 and verify it displays a signal similar to the previously shown Figure 5-31, except the amplitude is typically 10V p-p. The measured amplitude may not be 10V p-p, for now just verify that the 1 kHz signal is present. If a failure is detected, skip to the Magnitude Control circuit troubleshooting in this section.
6. Check the High Voltage Control in the 1100V dc Range. Set the Calibrator to +220V dc, operate. Using a DMM, measure the dc voltage across capacitor C1 and verify it is 227V ±1V. A problem with the Magnitude Control circuit may cause this voltage to be much greater than 227V. If no dc voltage is present check T1, K9, K6, CR1-

CR4, and associated components. If the measure voltage is much greater than 227V skip to the Magnitude Control Circuit troubleshooting starting at step 10.

7. Check HV OUT from the High Voltage Control assembly. Set the Calibrator to +220V dc, operate. Using a DMM measure the dc voltage at pin 1A or 1C of P611 and verify it reads +220V ±0.2V. If a failure is detected, check K4, K11, K5, K12, K3, and associated components.

Note

The following steps 8 and 9 check the operation of the High Voltage Control assembly in the 2.2A Current Range. For these checks it will be necessary to install a jumper connecting the front panel OUTPUT HI binding post to the OUTPUT LO binding post. If may be useful to refer to Figure 2-27 in the Theory of Operation Section.

8. Check the output from the Magnitude control circuit. Set the Calibrator to 220 mA dc at 1 kHz, operate. Connect an oscilloscope to TP3 and verify it displays a signal similar the previously shown Figure 5-31, except the amplitude is typically 40V p-p. The measured amplitude may not be 40V p-p, for now just verify that the 1 kHz signal is present. If a failure is detected, skip to the Magnitude Control circuit troubleshooting in this section.
9. Check the High Voltage Control assembly in the 2.2A Range. Set the Calibrator to 220 mA at 1 kHz, operate. Connect the DMM low to VICOM (pins 16A/C of P612) and the DMM high to VI+ (pins 15A/C of P612)and verify it is +5.3V ±10%. Next, move the DMM high to VI- (pins 14A/C of P612) and verify it is -5.3 ±10%. If a failure is detected, check T1, K14, K2, CR5, and associated components in the 2A Range Power Supply Filter circuit.

Note

Remove the front panel jumper connecting OUTPUT HI to OUTPUT LO before continuing.

Magnitude Control Circuit *5-20.*

Proceed as follows to troubleshoot the magnitude control circuit:

1. Check the Square Wave Generator. Power down the Calibrator and connect the oscilloscope, set for 2V/div and 500 us/div, to TP2. When the Calibrator is turned on, the oscilloscope should display a TTL-level 1 kHz square wave for approximately 1 second. If a failure is detected, check U4, U7A, and associated components in the Square Wave Generator.
2. Check the Reference and Error Amplifier. Power down the Calibrator and connect an oscilloscope, set for 5V/div, to the cathode of CR10. At power up of the Calibrator the oscilloscope should display a dc voltage which ramps up to approximately +14V and remains there for approximately 1 second before returning to 0V. If a failure is detected, check U2D, U7B, Q2, Q4, VR1, and associated components in the Reference and Error Amplifier circuit.
3. Check the Square Wave Amplifier. Power down the Calibrator and connect an oscilloscope, set for 5V/div, to pin 1 of U1. At power up of the Calibrator the oscilloscope should display a dc voltage which ramps down to approximately -14V and remains there for approximately 1 second before returning to 0V. If a failure is detected, check U1A and associated components. If this voltage is correct and at

power up there is still no signal at TP3 during power up then check U3, U7C/D, and associated components in the Square Wave Amplifier circuit.

4. Check the Absolute Value Circuit. Add a jumper connecting the front panel OUTPUT HI binding post to the OUTPUT LO binding post. Set the Calibrator to 1.0A at 1 kHz, operate. Connect an oscilloscope to G OUT(pin 12C of P612) and Note the amplitude of the positive wave peaks. Next, connect the oscilloscope to U2 pin 7 and verify the dc voltage is equal the previously Noted positive peaks of ac voltage. If a failure is detected, check U2A, U2B, and associated components in the Absolute Value Circuit.

Note

Remove the front panel jumper connecting OUTPUT HI to OUTPUT LO before continuing.

5. Check the Signal/Polarity Selection. Set the Calibrator to 220V dc operate. Using a DMM measure the dc voltage at TP4 and verify it is +6 to +8V. Next, set the Calibrator to -220V dc operate and again verify that the dc voltage at TP4 remains between +6 and +8V. If a failure is detected, check U2C, U6, and associated components in the Signal/Polarity Selection circuit.

Troubleshooting the High Voltage/High Current Assembly (A15) 5-21.

Proceed as follows to troubleshoot the High Voltage/High Current Assembly (A15):

1. Remove the rear shield from the High Voltage/High Current assembly and place it on the extender card. All measurements will be referenced to ACOM (TP7) unless Noted otherwise. Power up the Calibrator and proceed as follows.

Warning

High voltages are exposed when troubleshooting the high voltage/high current assembly.

2. Check the ±20S supplies. Set the Calibrator to 0V dc, standby. Measure with a DMM the dc voltage at the cathode of VR3 and verify it is 20V±5%. Next, measure the dc voltage at the anode of VR4 and verify it is -20V ±5%. If a failure is detected, check VR3, VR4, and associated components.
3. Check the power-up standby voltages. Set the Calibrator to 0V standby. Using a DMM measure the dc voltage at TP5 and verify it is 0V ±50 µV. If a failure is detected, proceed with step 4, otherwise skip to step 6.
4. Check Buffer U1. Measure the dc voltage at TP3 and Note the polarity. Next, measure the dc voltage at TP5 and verify that it is the opposite polarity. If a failure is detected, check U1 and associated components.
5. Check the HR7 Hybrid and U2. Measure the dc voltage at pin 10 of the HR7 Hybrid and Note the polarity. Next, measure the dc voltage at TP3 and check that it is the opposite polarity. If a failure is detected, check the HR7 Hybrid, U2, and associated components.
6. Check -SP C and +SP C at power up standby. Using a DMM, measure the dc voltage at TP4 (-SP C) and verify it is between +13.2 and +14.2V. Next measure the dc voltage at TP6 (+SP C) and verify it is between-0.1 and -0.3V. If a failure is detected, check Q3, Q4, Q6, and associated components in the HV DC Output Series Pass & Current Limit circuit.

7. The following step 8 checks the High Voltage/High Current assembly in the 1100V ac range. To better understand of function of this assembly during this mode of operation refer to Figure 2-25 in the Theory of Operation section. During normal operation in the 1100V ac mode, internal software monitors the output and makes corrections or trips the instrument into standby. This internal monitoring can cause difficulty when troubleshooting a faulty High Voltage assembly. If during the next step 8 the instrument keeps tripping into standby, defeat the monitoring by connecting a jumper from TP9 to TP10 on the DAC assembly.
8. Check the 1100V ac range. Set the Calibrator to 220V at 130 Hz, operate. Using a DMM, measure the ac voltage at pin 1 of the HR7 resistor network. Note the DMM reading and verify it is 220V ac ±0.1V. Next, measure the voltage at TP5 and verify it is 1/100th of the voltage Noted at pin 1 of the HR7 resistor network. If a failure is detected, check the HR7 Hybrid assembly, U2, U1, K6, K1, K4, and associated components.

Note

Remove the jumper connecting TP9 to TP10 on the DAC assembly before continuing. Steps 10 through 12 check the High Voltage/High Current assembly in the 1100V dc range. To better understand the function of this assembly during this mode of operation, refer to Figure 2-26 in the Theory of Operation section.

9. Check the 1100VDC Range input voltage. Set the Calibrator to 220V dc, operate. Using a DMM measure the dc voltage at TP1 and verify it is-2.2V ±1 mV. If a failure is detected, check K1 and its drive circuit.
10. Check the 1100VDC Range DC HV Amplifier. Set the Calibrator to 220V dc, operate. Measure the dc voltage at TP3 with a DMM and verify it is 0.55±0.2V. Next, set the Calibrator to -220V dc, operate. Again measure the dc voltage at TP3 and verify it is now 2.3±0.2V. If a failure is detected, check the HR7 Hybrid assembly, U2, K5, K7, K14, and associated components.
11. Check -SP C and +SP C in the 1100V dc range. Set the Calibrator to +220 Vdc, operate. Using a DMM, measure the dc voltage at TP4 (-SP C) and verify it is between +13.2 and +14.2V. Also measure the dc voltage at TP6 (+SP C) and verify it is between -6 and -8V. Next, set the Calibrator to -220V dc, operate. Again measure the dc voltage at TP4 and TP6. In this mode TP4 should be between +6 and +8V, and TP6 should be between -13.2 and -14.2V. If a failure is detected, check Q3, Q4, Q6, and associated components.

Note

Steps 12 through 14 check the High Voltage/High Current assembly in the 2.2A Current range. For these checks it will be necessary to install a jumper connecting the front panel OUTPUT HI binding post to the OUTPUT LO binding post. To better understand the function of this assembly during this mode of operation refer to Figure 2-27 in the Theory of Operation section.

12. Remove the hybrid cover from the H4 assembly. Unsolder the right end of resistor R37 (node with R37, Z5 pins 2 and 3), labeled G+ on the schematic, and lift this end out of the circuit board. Connect an external ac reference to the lifted end of R37 and reinstall the assembly on the extender card. Power up the Calibrator. Set the external ac reference to 1V at 1 kHz and connect an oscilloscope to the output of the H4 Hybrid (node with R42, R44, and H4 pin 18). Verify the oscilloscope displays a

square wave similar to Figure 5-32. If a failure is detected, check the H4 Hybrid assembly.

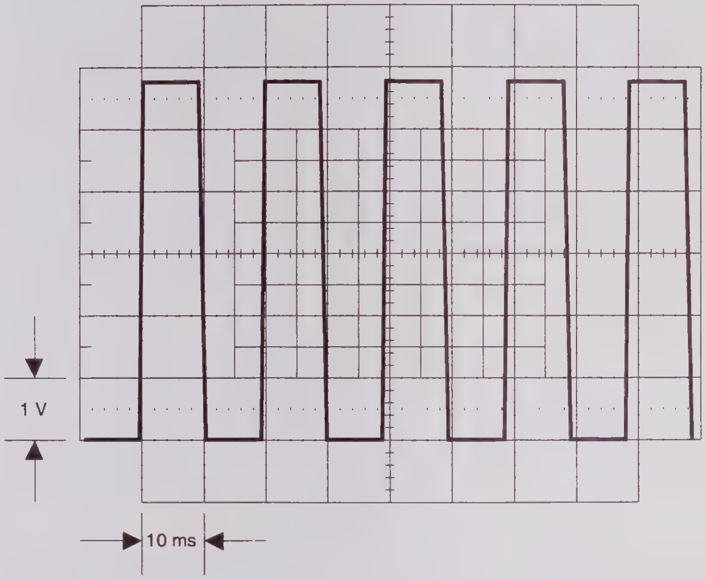

Figure 5-32. Waveform at Pin 18 of Hybrid H4

13. Connect an oscilloscope to pin 7 of U3B and verify it displays a square wave equal to the positive peaks of Figure 5-32. Next, connect the oscilloscope to pin 1 of U3A and verify it displays a square wave equal to the negative peaks of Figure 5-32. If a failure is detected, check U3 and associated components.

Note

Reinstall the lifted end of R37, solder it to the circuit board, and reinstall the H4 Hybrid cover before continuing.

14. Check the 2.2A current range. Set the Calibrator to 0A in the 2.2A Range by range locking the instrument in the 2.2A range and calling up 0A. Using a DMM, measure the dc voltage across R57 and verify it is 0.028V ±25%. Next, measure the dc voltage across R68 and verify it is 0.028V ±25%. If a failure is detected, check U4, U5, Q11-Q16, and associated components.

Troubleshooting the Power Amplifier Assembly (A16) 5-22.

Note

During normal Calibrator operation, internal software monitors the output and makes corrections or trips the instrument to standby. This internal monitoring can cause problems when attempting to troubleshoot the Power Amplifier assembly. Defeat the monitoring by connecting a jumper from TP9 to TP10 on the DAC assembly and another jumper connecting TP1 on the Oscillator Output (A13) assembly to the bottom of R8 (node with R8, C42, C43, and pin 6 of U6) on the Oscillator Control (A12) assembly.

After disabling the internal moitoring loop, remove the rear shield and front air duct from the Power Amplifier assembly. Place the assembly on the extender card and proceed as follows to troubleshoot the Power Amplifier assembly (A16):

1. Power up the Calibrator. In the following steps, reference all measurements to PACOM (TP10) unless otherwise Noted.
2. Set the Calibrator to 22V at 1 kHz, operate. This configures the Power Amplifier assembly as an amplifier with a gain of -10 as shown in Figure 5-33. Check the input for the correct voltage. Using a DMM, measure the ac voltage at TP3 and verify it is 2.2V ±5%. If this voltage is incorrect, check relay K10A and its drive circuit. Next, measure the output of the Power Amplifier. Using a DMM, measure the voltage at TP6 and verify it is 10 times that measured at TP3 ±5%. Also measure the dc offset at TP6 and verify it is less than 10 mV. If this voltage is incorrect, proceed with step 3. If the output voltage is correct skip to step 8.

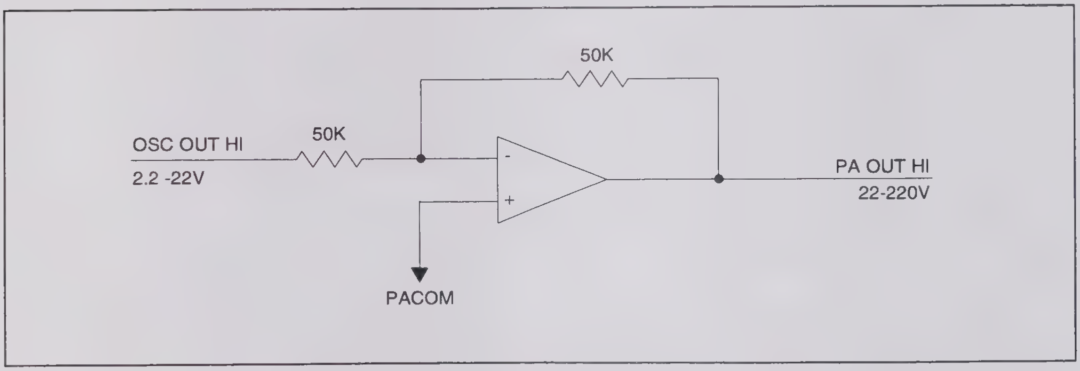

Figure 5-33. Power Amplifier with Calibrator Set to 22V at 1 kHz

3. Before troubleshooting the main Power Amplifier loop, switch the ±PA supplies to the low voltage (±40SR Supplies) mode by switching switch SW201 on the Filter/PA Supply assembly. Using a DMM, measure the ±PA supplies and verify they are ±60V ±15V. If a failure is detected, the Filter/ PA Supply assembly may be at fault.
4. Check the Bias Current circuit. Set the Calibrator to 0V dc, standby. Connect an external 100Ω 1/4W carbon-film resistor between PACOM (TP10) and 1ST MID STAGE OUT which is the left side of 1W resistor R41. Using a DMM, measure the mid stage output (1ST MID STAGE OUT),which is the left side of R41, and verify the dc voltage is either +0.8V ±0.2V or -1.1V ±0.2V. If this voltage is correct skip to step 6. If it is incorrect, remove Q12 from the assembly and recheck the Mid-Stage output. With Q12 removed, the Mid-Stage output should be 0.8V ±0.2V. If this voltage is incorrect, check CR53, Q31, Q32, and associated components in the Current Source Circuit. If the voltage is correct then the Input Stage or Mid-Stage circuitry is probably at fault.
5. Check the Input Stage and Mid-Stage. Set the Calibrator to 0V dc, standby. Using a DMM check measure the voltage at pin 10 of the HR8 hybrid and Note whether it is positive or negative. Next, measure the Input Stage output at TP4 and verify it is properly inverting. If a failure is detected, the Input Stage circuit is probably at fault. If the Input Stage is properly inverting, the Mid-Stage circuit is probably at fault.
6. Check the Output Stage Bias Current. Set the Calibrator to 0V dc, standby. Connect an external 100Ω 1/4W carbon-film resistor between PACOM (TP10) and 1ST MID STAGE OUT which is the left side of 1W resistor R41. Using a DMM measure the Output Stage bias current by measuring the dc voltage between TP14 and TP15,

verify it is 0.92V±20%. If a failure is detected, check Q7, Q4, Q5, Q10, Q11, and associated components.

7. Check the output of the Output Stage. Set the Calibrator to 0V dc, standby. Connect an external 100Ω 1/4W carbon-film resistor between PACOM (TP10) and 1ST MID STAGE OUT, which is the left side of 1W resistor R41. Measure the dc voltage at the Mid-Stage output as is step 4. If the voltage is +0.8V, then the voltage at TP6 (PA OUT HI)should be +3.2±0.3V. If the voltage measured at the Mid-Stage output is -1.1V, then the voltage at TP6 should be +1.3±0.3V. If a failure is detected, check the components in the Output Stage Circuit.

Note

If switch SW201 on the Filter/PA Supply assembly was set to the low voltage mode, switch it back to the normal(±PA) mode before continuing.

8. Check the 220V RANGE AC ATTENUATOR. Connect a jumper from TP9 to TP10 on the DAC assembly and another jumper connecting TP1 on the Oscillator Output (A13) assembly to the bottom of R8 (node with R8, C42, C43, and pin 6 of U6) on the Oscillator Control (A12) assembly as done in the previous step 1. Set the Calibrator to 22V at 1 kHz, operate. Testing of this 220V Range AC Attenuator is divided into three steps. Measure the ac voltage with a DMM at TP6 (the Power Amplifier output), then measure the voltage at TP7 (Attenuator input) and verify they are the same ±10 mV. If a failure is detected, check relay K16B and its drive circuit.

Note

If relay K16B is not at fault, then PA OUT HI may be open from PA SENSE AC elsewhere in the Calibrator.

9. Measure the ac voltage at TP8 with a DMM and verify it equals the voltage measured at TP7 divided by 100 ±1%. Also use an oscilloscope and check for any distortion at TP8. If a failure is detected, check Z1, U4, Q58, Q54, and their associated components. Next, using a DMM, measure the ac voltage at pin 8 of K11 and verify it is the same as measured at TP8. If a failure is detected, check relays K10B, K11, and their drive circuit.

10. Check the SC+ and SC- supplies. Set the Calibrator to 0V dc, standby. Using a DMM, measure the SC+ supply at U1 pin 7 and verify it is +18V ±10%. Next, measure the DC- supply at U1 pin 4 and verify it is -15V ±10%. If a failure is detected, check zener diodes VR15 and VR18.

Note

Remove any jumpers left in place from step 8 before continuing.

11. Check the SENSE CURRENT CANCELLATION circuit. Set the Calibrator to 100 Vdc, operate. Using a DMM, measure the voltage between pin 6 of U1 and TP1, and verify it is 2V ±25 mV. If a failure is detected, check U1 and its associated components.

Note

Step 12 should be done only when a problem with calibration of the 220V dc range exists.

12. Check the 220V DC INT. CAL. NETWORK. Set the Calibrator to 0V dc, standby. Connect a jumper from U5 pin 1 to SCOM (TP11). Using a DMM measure the 13V reference at TP2 of the DAC assembly (common to TP3)and Note the reading. Next, measure the buffered 13V reference at TP12 of the Power Amplifier and verify it is the same. If a failure is detected, check U5, K3, and their drive circuit. Next, using a

DMM, measure the voltage at U9 pin 6 and verify it is the equal to the voltage at TP12 divided by 8 ±1%. If a failure is detected, check the HR8 resistor network, U9, and the associated components.

Troubleshooting the Filter/PA Supply Assembly (A18) 5-23.

Proceed as follows to troubleshoot the Filter/PA Supply assembly (A18):

1. Place the Filter/PA Supply assembly on the extender card. Remove the Power Amplifier assembly (A16) and power up the Calibrator. Reference all measurements to PACOM (TP203). The Calibrator should be in its power-up default standby condition unless otherwise Noted.
2. Check the unregulated ±250V Supplies. Using a DMM, measure the dc voltage at the cathode of CR235 or CR239 and verify it is -280V±10%. Next, measure the dc voltage at the anode of CR208 or CR203 and verify it is +280V ±10%. Connect an oscilloscope to these points and verify the ripple is less than 5V p-p. If a failure is detected, check CR222, F202, F203, and associated components.
3. Check the unregulated ±500V Supplies. Using a DMM measure the dc voltage at TP209 and verify it is +565 ±10%. Next, measure the dc voltage at TP211 and verify it is -565 ±10%. Connect an oscilloscope to these points and verify the ripple is less than 5V p-p. If a failure is detected, check CR217, CR218, CR220, CR221, CR223, CR224, CR227, CR228, F201, F204, and associated components.
4. Check the Control Lines. Using a DMM, measure the dc voltage at TP205, TP207, and TP208. Verify they are all at +12V ±4V. Next measure the dc voltage at pins 13 and 14 of U201. Verify they are at- 12V ±4V. If a failure is detected, check Z201, U201A, U201B, and associated components.
5. Check the unregulated +250V Supply. Using a DMM, measure the dc voltage at TP210 and verify it is +280 ±10% If a failure is detected, measure the voltage at the cathode of VR211 and verify it is +140 ±20%. If this voltage is incorrect, check VR211, VR214, VR215, VR219, and Q208. If the voltage at the cathode of VR211 is correct then check Q201, CR201, CR203, CR208, CR210, and associated components.
6. Check the regulated +PA Supply at 0V. Using a DMM measure the dc voltage at TP201 and verify it is less than 1.0V. If a failure is detected, check Q207.
7. Check the regulated +PA Supply at +180V. Jumper TP207 to PACOM (TP203), measure the +PA Supply at TP201 and verify it is +190V±10%. If this voltage is correct, skip to step 8, otherwise continue as follows. Measure the output of the Current Limit circuit. Connect a DMM to pin 1 of U201 and verify it is -12±4V. If this voltage is incorrect, then the +PA Supply is current-limited. Check the output for shorts and check the current-limiting circuit contained in U201C, Q203, Q206, and associated components. If the voltage at pin 1 of U201 is correct, check Q205, Q202, VR212, VR207, and associated components.
8. Check the unregulated +PA Supply at +360V. Jumper TP207 and TP205 to PACOM (TP203), measure the voltage at TP210 and verify it is +480V±10%. If a failure is detected, check Q208, VR214, VR215, VR219, CR201, CR203, CR208, CR210, and associated components. Next, check the regulated +PA Supply at TP201 and verify it is +370V ±10%. If a failure is detected, check Q205 and VR216.
9. Check the Current Limiting of the +PA Supply. Jumper TP207 to PACOM (TP203) and remove the jumper connecting TP205 to LO HI I (TP206). Connect an oscilloscope to the +PA Supply at TP201. Connect a 1 kΩ 10W resistor (such as Fluke P/N 157933) between PACOM (TP203) and the +PA supply output at Jumper

J201. The +PA supply (at +180V)should go into current limit. The oscilloscope should show a repeating pattern in which the +PA supply climbs to about +180V then drops to 0V. If a failure is detected, check Q203, VR246, VR213, U201C, and associated components.

10. Check the unregulated -250V Supply. Using a DMM, measure the dc voltage at TP212 and verify it is -280V ±10%. If a failure is detected, measure the voltage at the anode of VR231 and verify it is-140V ±20%. If this voltage is incorrect, check VR231, VR230, VR229, VR225, and Q209. If the voltage at the anode of VR231 is correct, then check Q215, CR234, CR235, CR239, CR243, and associated components.
11. Check the regulated -PA Supply at 0V. Using a DMM, measure the dc voltage at TP204 and verify it is less than 1.0V. If a failure is detected, check Q212.
12. Check the regulated -PA Supply at -180V. Jumper TP207 to PACOM (TP203), measure the -PA Supply at TP204 and verify it is -190V±10%. If this voltage is correct, skip to step 13, otherwise continue as follows. Measure the output of the Current Limit circuit. Connect a DMM to pin 2 of U201 and verify it is +12±4V. If this voltage is incorrect, then the -PA Supply is in current limit. Check the output for shorts and check the current-limiting circuit contained in U201D, Q211, Q214, and associated components. If the voltage at pin 2 of U201 is correct check Q210, Q216, VR232, VR238, and associated components.
13. Check the unregulated -PA Supply at -360V. Jumper TP207 and TP208 to PACOM (TP203), measure the voltage at TP212 and verify it is-480V ±10%. If a failure is detected, check Q209, VR225, VR229, VR230, CR234, CR235, CR239, CR243, and associated components. Next, check the regulated -PA Supply at TP204 and verify it is -370V±10%. If a failure is detected, check Q210, and VR226.
14. Check the Current Limiting of the -PA Supply. Jumper TP207 to PACOM (TP203) and remove the jumper connecting TP208 to LO HI I (TP206). Connect an oscilloscope to the -PA Supply at TP204. Connect a 1 kΩ 10W resistor (such as Fluke P/N 157933) between PACOM (TP203) and the -PA supply output at Jumper J202. The -PA supply (at -180V)should go into current limit. The oscilloscope should show a repeating pattern in which the -PA supply climbs to about -180V then drops to 0V. If a failure is detected, check Q214, VR247, VR233, U201D, and associated components.

Chapter 6
List of Replaceable Parts

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6-2. How to Obtain Parts 6-3
6-3. Manual Status Information 6-3
6-4. Newer Instruments 6-4
6-5. Service Centers 6-4

6-1. Introduction

This section contains an illustrated list of replaceable parts for the 5700A/5720A Series II. Where applicable, parts differences are indicated between the 5700A and 5720A. For example, Table 6-1 indicates MP36 (nameplate) is PN 600723 for a 5700A or PN 600759 for a 5720A. Parts are listed by assembly; alphabetized by reference designator. Each assembly is accompanied by an illustration showing the location of each part and its reference designator. The parts lists give the following information:

- Reference designator
- An indication if the part is subject to damage by static discharge
- Description
- Fluke stock number
- Manufacturers supply code
- Manufacturers part number or generic type
- Total quantity
- Any special notes (i.e., factory-selected part)

CAUTION

A * symbol indicates a device that may be damaged by static discharge.

6-2. How to Obtain Parts

Electrical components may be ordered directly from the manufacturer by using the manufacturers part number, or from the Fluke Corporation and its authorized representatives by using the part number under the heading FLUKE STOCK NO. In the U.S., order directly from the Fluke Parts Dept. by calling 1-800-526-4731. Parts price information is available from the Fluke Corporation or its representatives. Prices are also available in a Fluke Replacement Parts Catalog which is available on request.

In the event that the part ordered has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

To ensure prompt delivery of the correct part, include the following information when you place an order:

- Instrument model and serial number
- Part number and revision level of the pca containing the part
- Reference designator
- Fluke stock number
- Description (as given under the DESCRIPTION heading)
- Quantity

6-3. Manual Status Information

The Manual Status Information table that precedes the parts list defines the assembly revision levels that are documented in the manual. Revision levels are printed on the component side of each pca.

6-4. Newer Instruments

Changes and improvements made to the instrument are identified by incrementing the revision letter marked on the affected pca. These changes are documented on a supplemental change/errata sheet which, when applicable, is included with the manual.

6-5. Service Centers

A list of service centers is located at the end of this section.

Manual Status Information

Ref or Option No.	Assembly Name	Fluke Part No.	Revision Level
A1	Keyboard PCA	761049	C
A2	Front Panel PCA	761031	F
A3	Analog Motherboard PCA	761023	C
A4	Digital Motherboard PCA	760942	G
A5	WideBand Output PCA	761346	J
A6	Wideband Oscillator PCA	761098	K
A7	Current/High-Resolution Oscillator PCA	764613	V
A8	Switch Matrix PCA	761106	T
A9	Ohms Cal PCA	775395	K
A10	Ohms Main PCA	761114	E
A11	DAC PCA	761122	P
A11A1	DAC Filter PCA	761395	B
A11A2	DAC Buffered Reference PCA	764639	A
A12	Oscillator Control PCA	761130	N
A13	Oscillator Output PCA	761148	R
A13A1	Oscillator Wideband PCA	761403	C
A14	High Voltage Control PCA	775429	H
A15	High Voltage/High Current PCA	761155	G
A16	Power Amplifier PCA	761163	U
A16A1	Power Amplifier Digital Control SIP PCA	775320	C
A17	Regulator/Guard Crossing PCA	761171	J
A18	Filter/PA Supply PCA	761189	P
A19	Digital Power Supply PCA	761056	H
A20	CPU PCA (5700A Series I)	761072	H
A20	CPU PCA (5700A Series II)	613429	H
A20	CPU PCA (5720A)	613437	H
A21	Rear Panel PCA	761221	K

Table 6-1. Front Panel Final Assembly

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
A1	* KEYBOARD PCA	761049	1	
A2	* FRONT PANEL PCA	761031	1	
A3	* ANALOG MOTHERBOARD PCA	761023	1	
A4	* DIGITAL MOTHERBOARD PCA	760942	1	
A7	* CURRENT/HIGHT RESOLUTION OSCILLTOR. PCA	764613	1	
A8	* SWITCH MATRIX PCA	761106	1	
A9	* OHMS,CAL PCA	775395	1	
A10	* OHMS,MAIN PCA	761114	1	
A11	* DAC PCA	761122	1	
A12	* OSCILLATOR CONTROL PCA	761130	1	
A13	* OSCILLATOR OUTPUT, PCA	761148	1	
A14	* HIGH VOLTAGE CONTROL PCA	775429	1	
A15	* HIGH VOLTAGE/HIGH CURRENT PCA	761155	1	
A16	* POWER AMPLIFIER PCA	761163	1	
A17	* REGULATOR./GUARD CROSSING PCA	761171	1	
A18	* FILTER/PA PCA	761189	1	
A19	* DIGITAL POWER SUPPLY PCA	761056	1	
A20	* CPU PCA	761072	1	
A21	* REAR PANEL PCA	761221	1	
A22	TRANSFORMER/MODULE ASSEMBLY	813527	1	1
CP1	ADAPTER,COAX,SMA(F),N(F)	516963	1	
E1	JUMPER LINK,BINDING POST	190728	1	
E2	GROUND STRIP,COPPER,1.00,.375,.030	854836	1	
H5	SCREW,PH,P,THD FORM,STL,5-20,..312	494641	9	
H20	SCREW,PH,P,LOCK,STL,4-40,.187	129882	4	
H25	SCREW,CAP,SCKT,SS,8-32,.375	837575	4	
H29	SCREW,FHU,P,LOCK,SS,6-32,.250	769893	3	
H32	SCREW,PH,P,LOCK,STL,6-32,.250	152140	11	
H43	SCREW,PH,P,LOCK,SS,6-32,.375	334458	1	
MP1	PANEL, FRONT, SHEET METAL	761437	1	
MP2	SHIELD, DISPLAY PWB	764514	1	
MP3	LENS, SHIELD	760843	1	
MP4	DECAL, FRONT OUTPUT CABLE DIAGRAM	802967	1	
MP6	GROMMET,EXTRUDED,POLYETHYLENE,.085	854351	1	
MP14	BINDING POST-RED	886382	3	
MP17	BINDING POST-BLACK	886379	2	
MP19	BINDING POST-GREEN	886374	1	
MP20	BINDING POST-BLUE	886366	1	
MP21	ENCODER WHEEL	764548	1	
MP22	FRONT PANEL, MOLDED	886325	1	
MP23	KNOB, ENCODER, GREY	868794	1	
MP24	KEYPAD,ELASTOMERIC	885397	1	
MP25	DECAL, POWER ON/OFF	886312	1	
MP26	DECAL, KEYPAD	886304	1	
MP27	DECAL, FRONT OUTPUT	886309	1	
MP28	NUT, #8 LOW THERMAL	850334	8	
MP35	LENS, DISPLAY	600756	1	
MP36	NAMEPLATE SET, ELECTROFORM (MODEL 5700A)	600723	1	
MP36	NAMEPLATE SET, ELECTROFORM (MODEL 5720A)	600759	1	
MP37	HANDLE,INSTRUMENT	886333	2	
TM1	5700A/5720 OPERATOR MANUAL	601622	1	
TM2	5700A/5720A SERVICE MANUAL	601630	1	
TM3	5700A/5720A SERIES GUIDE SET	601960	1	

1. See Figure 6-1a.

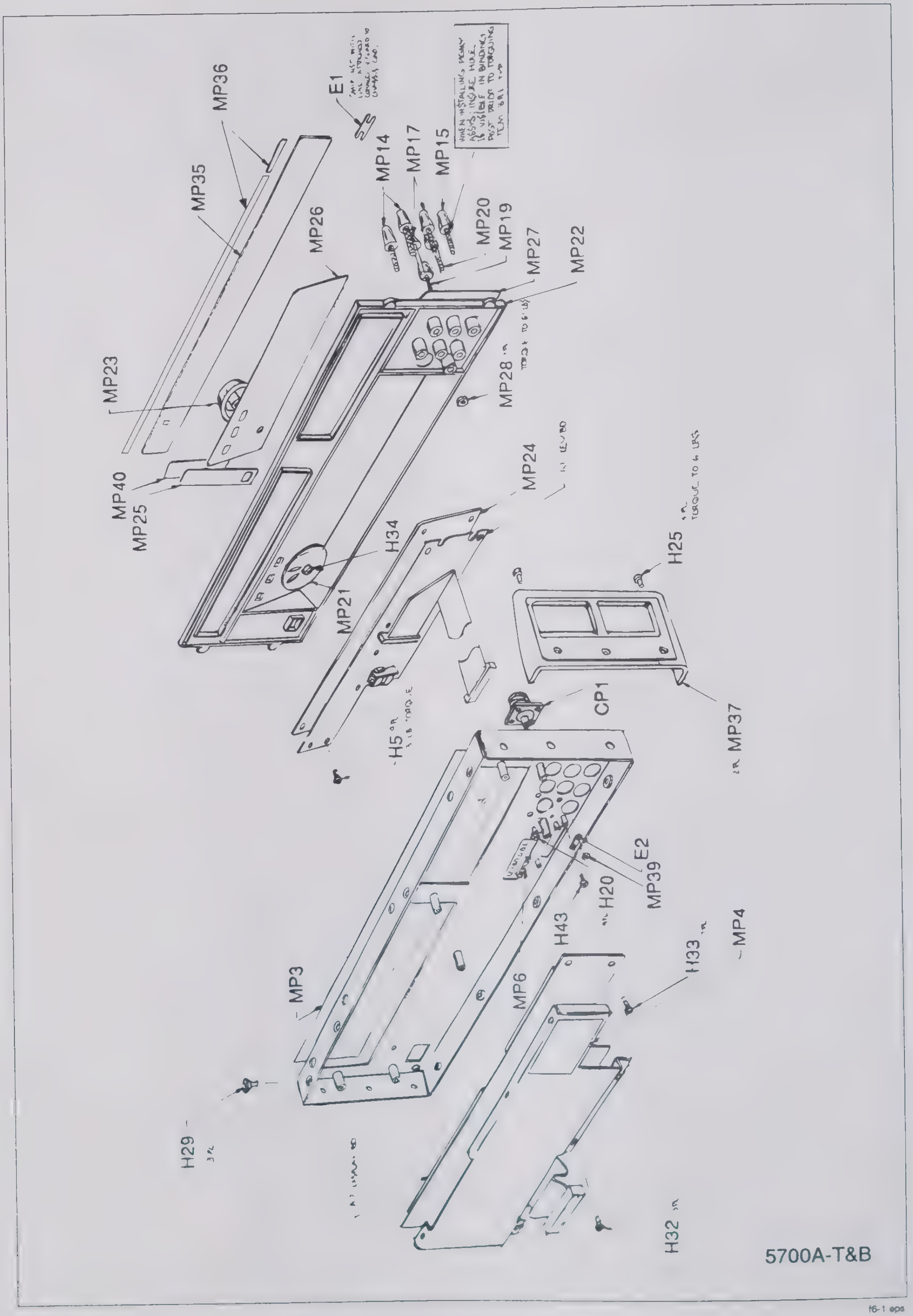
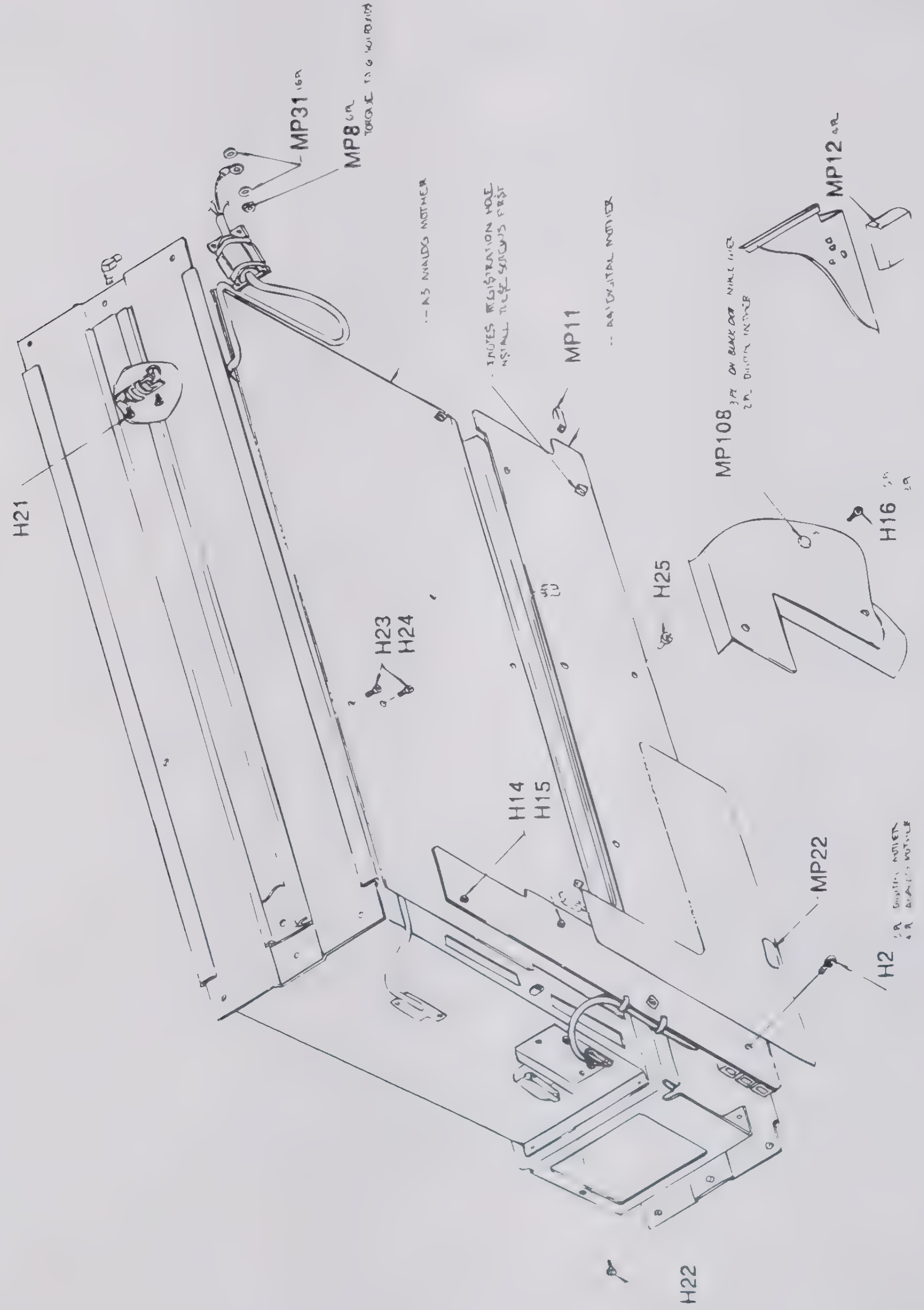


Figure 6-1. Front Panel Final Assembly

Table 6-1. Chassis Final Assembly

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
A22	TRANSFORMER/MODULE ASSEMBLY	813527	1	1
B1,B2	FAN/CONNECTOR ASSEMBLY	761213	2	
E1	BINDING HEAD, PLATED	102889	1	
F1	FUSE,.25X1.25,1.25A,250V,SLOW	851936	1	
H1	INSULATOR, ANALOG BOTTOM	775361	1	
H2	SCREW,PH,P,LOCK,SS,6-32,.500	320051	9	
H14	SCREW,PH,P,LOCK,STL,6-32,.750	114223	14	
H21	SCREW,PH,P,LOCK,STL,6-32,.250	152140	27	
H43	SCREW,PH,P,LOCK,STL,6-32,.375	152165	2	
H45	SCREW,CAP,SCKT,SS,8-32,.375	295105	12	
H57	SCREW,FHU,P,LOCK,SS,6-32,.250	769893	17	
H74	SCREW,PH,P,LOCK,STL,6-32,1.250	159756	8	
H85	WASHER,FLAT,STL,.149,.375,.031	110270	4	
H97	WASHER,FLAT,STL,.160,.281,.010	111005	10	
H105	SCREW,TH,P,LOCK,STL,8-32,.250	853622	4	
MP1	COVER, DIGITAL	775635	1	
MP2	BOTTOM COVER, ANALOG BOX	764530	1	
MP3	TOP COVER, ANALOG BOX	764522	1	
MP4	RELAY BRACKET	761015	1	
MP5	TOP COVER, INSTRUMENT	886395	1	
MP6	BOTTOM COVER, INSTRUMENT	886403	1	
MP7	SHROUD, CPU CABLE	813519	1	
MP8	NUT, #8 LOW THERMAL	850334	8	
MP11	POWER BUTTON, ON/OFF	775338	1	
MP12	BOTTOM FOOT, MOLDED, GRAY #7	868786	4	
MP18	SIDE EXTRUSION	886288	2	
MP20	ADHESIVE SIDE TRIM	698316	2	
MP22	DECAL, CAUTION 240V	760926	2	
MP23	DECAL, CAUTION 900V	760934	1	
MP31	WASHER, LOW THERMAL #8	859939	16	
MP45	INSERT EXTRUSION	886283	2	
MP47	INSULATOR, DIGITAL MOTHERBOARD	761247	1	
MP54	AIDE,PCB PULL	541730	2	
MP108	FOOT,RUBBER,ADHES,GRY,.44 DIA,.20 THK	358341	3	
MP114	GROMMET,SLOT,RUBBER,.438,.062	853291	1	
W1	CABLE, WIDEBAND TO FRONT PANEL	802785	1	

1. Non-repairable part.



5700A T&B
(1 of 2)

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Figure 6-2. Chassis Final Assembly

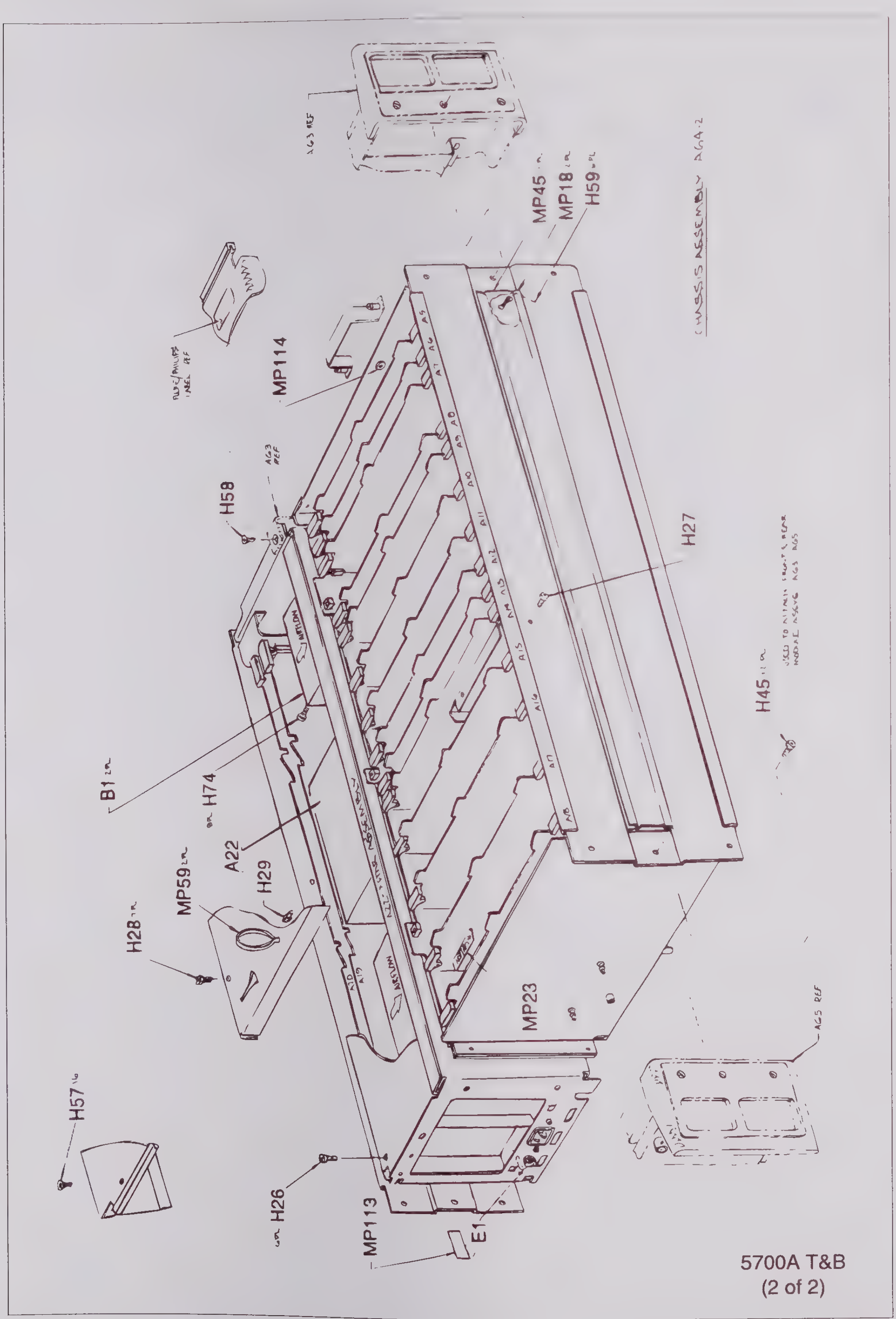

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Figure 6-2. Chassis Final Assembly (cont)

Table 6-1. Rear Panel Final Assembly

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
F1	FUSE,.25X1.25,1.25A,250V,SLOW	851936	1	
H1	FILTER, AIR	813493	1	
H3	SCREW,CAP,SCKT,SS,8-32,.375	837575	4	
H7	SCREW,PH,P,LOCK,STL,6-32,.750	114223	6	
H13	SCREW,PH,P,LOCK,STL,6-32,.250	152140	1	
MP1	REAR PANEL	886387	1	
MP2	GROMMET,EXTRUDED,POLYETHYLENE,.085	854351	1	
MP3	DECAL, REAR OUTPUT CABLE DIAGRRAM	886291	1	
MP5	GROMMET,NYLON,NAT,.056X.150X.100X.155	285254	1	
MP11	CONN ACC,MICRO-RIBBON,JACK SCREW	681940	2	
MP13	CONN ACC,D-SUB,JACK SCREW,4-40	448092	8	
MP21	ALUMINUM REAR OUTPUT HOUSING	885462	1	
MP22	MOLDED HOUSING, REAR OUTPUT	886358	1	
MP23	DECAL, REAR OUTPUT	886296	1	
MP24	FILTER FRAME	886390	1	
MP25	NUT, #8 LOW THERMAL	850334	6	
MP31	HANDLE,INSTRUMENT	886333	2	
MP33	BINDING POST-RED	886382	2	
MP35	BINDING POST-BLACK	886379	2	
MP37	BINDING POST-BLUE	886366	1	
MP38	BINDING POST-PURPLE	886361	1	
MP43	WASHER,FLAT,SS,.119,.187,.010	853296	8	
MP51	WASHER, LOW THERMAL	760892	4	
MP55	NUT, LOW THERMAL	760876	2	
MP106	WASHER,FLAT,STL,.191,.289,.010	111047	2	
MP125	WASHER,FLAT,STL,.160,.281,.010	111005	6	
W1	CORD,LINE,5-15/IEC,3-18AWG,SVT,7.5 FT06	284174	1	
W2	AC LINE FILTER ASSY	775445	1	

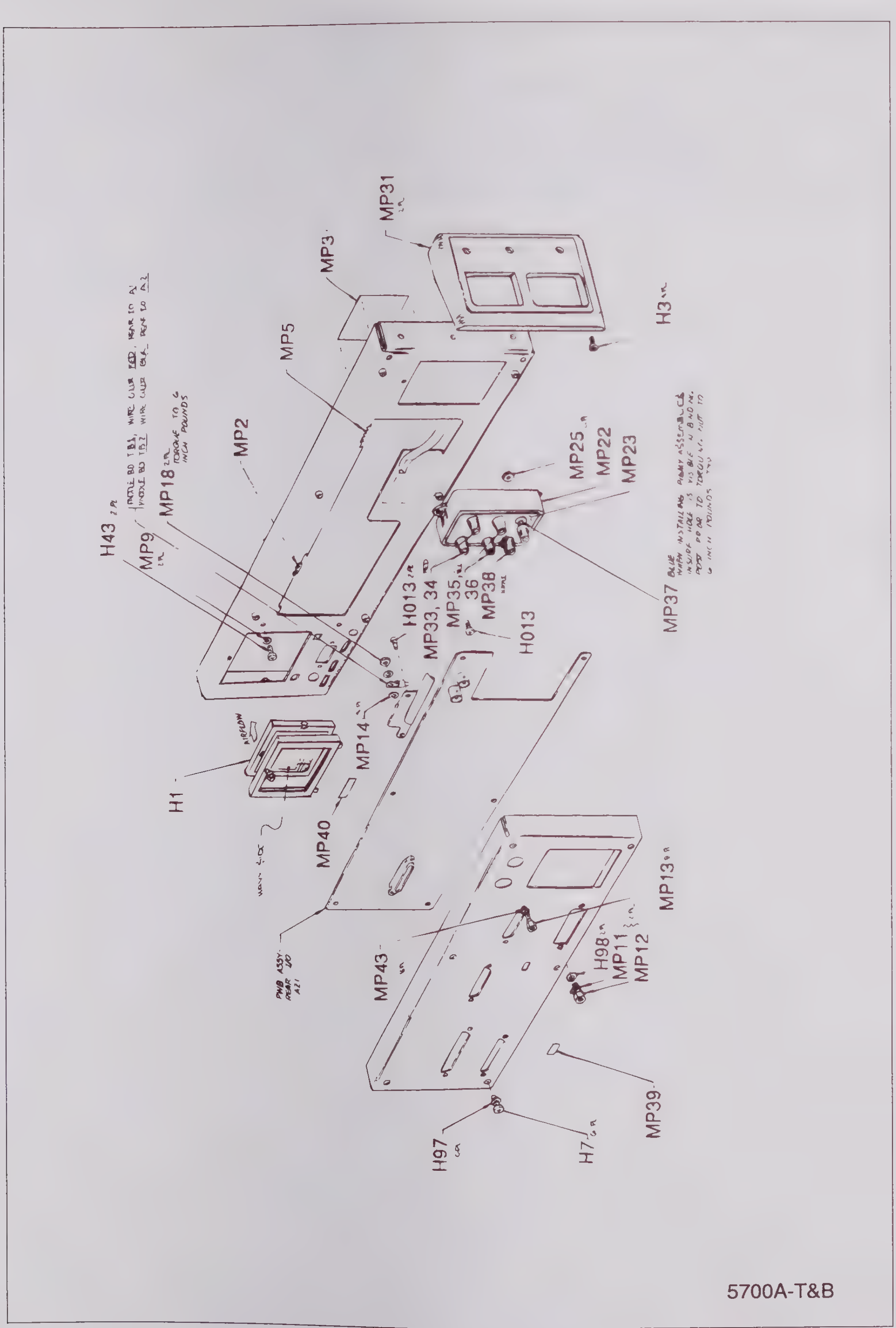
MP31
MP3
MP5
MP2
H43
MP9
MP18
TRIPLE BD TB1, WIRE COLOR RED, REAR TO A1
MIDDLE BD TB2 WIRE COLOR BLK, REAR TO A2
TORQUE TO 6 INCH POUNDS
H3
MP25
MP22
MP23
MP37
BLUE
WHEN INSTALLING BINDING POST ASSEMBLIES INSIDE HOLE IS VISIBLE IN BINDING POST. TORQUE NUT TO 6 INCH POUNDS
H013
MP33, 34
MP35,
36
MP38
H013
MP14
AIRFLOW
H1
MP40
PWB ASSY REAR I/O A21
MP43
MP13
H98
MP11
MP12
MP39
H97
H7
5700A-T&B
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Figure 6-3. Rear Panel Final Assembly

Table 6-2. A1 Keyboard PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
CR1-4	LED,GREEN,SUBMINIATURE	912241	4	
DT1, DT2	* ISOLATOR,OPTO,OPTICAL SWITCH,INFRARED	523530	2	
W1	CABLE, KEYBOARD/REAR PANEL	791657	1	

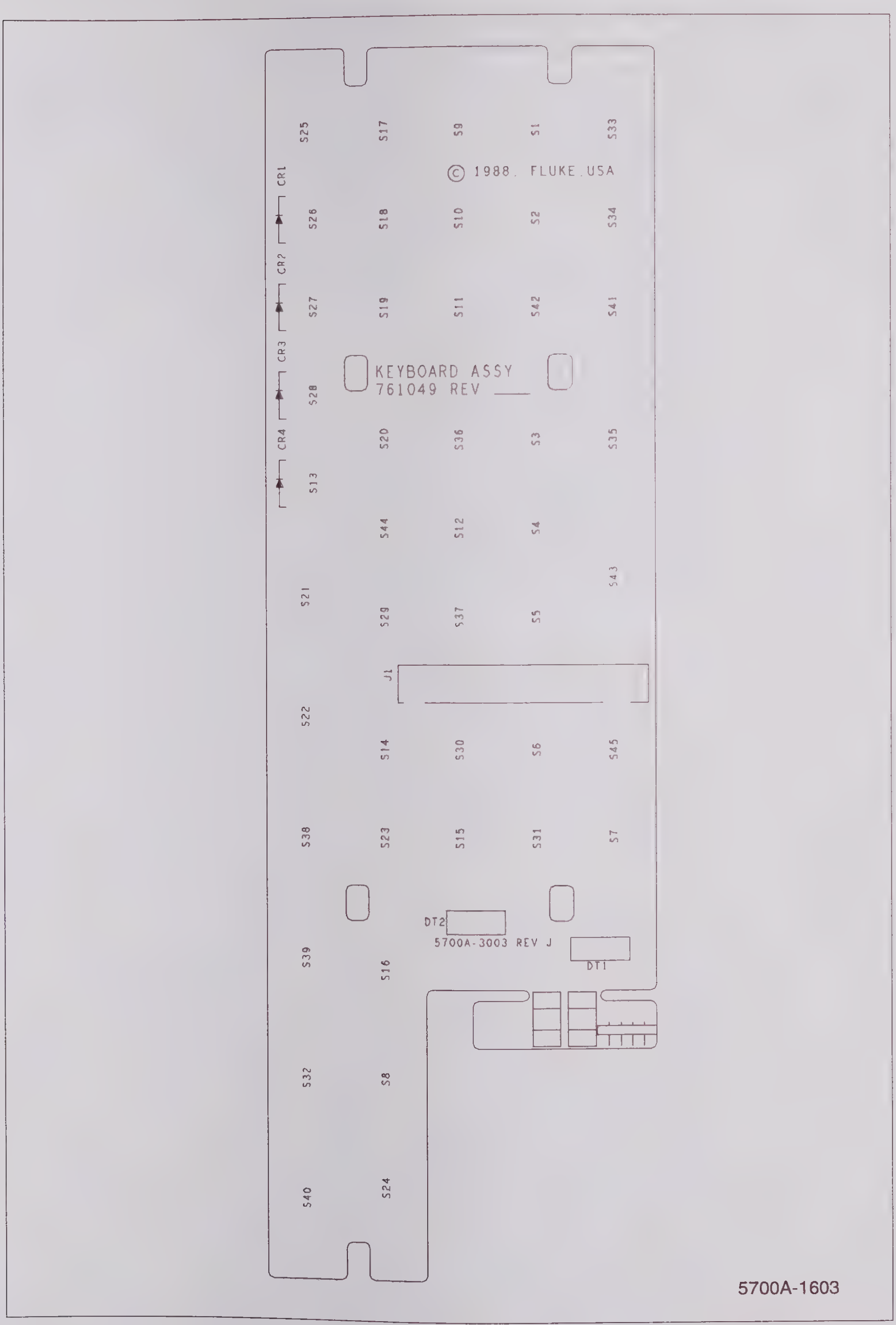

Figure 6-4. A1 Keyboard PCA

Table 6-3. A2 Front Panel PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1	CAP,TA,47UF,+-20%,10V	746990	1	
C2,C4,C9-20,C28, C30,C35,C37, C39-046,C64	CAP,CER,0.1UF,+-10%,25V,X7R,1206	747287 747287 747287	27	
C3,C21-27,C29, C31,C36,C38, C47-50,C66	CAP,TA,10UF,+-20%,25V,6032	927814 927814 927814	17	
C5,C33,C65	CAP,TA,1.5UF,+-20%,50V,6032	929302	3	
C6,C8,C32	CAP,CER,0.01UF,+-20%,100V,X7R,1206	742981	8	
C7	CAP,AL,10UF,+-20%,100V,SOLV PROOF	820738	1	
C55-59,C061,C62	CAP,POLYES,0.68UF,+-20%,100V	912506	7	
C60	CAP,POLYES,0.68UF,+-20%,100V	912506	1	
C63	CAP,CER,100PF,+-10%,50V,C0G,1206	740571	1	
DS1	TUBE, DISPLAY, VAC FLOR,2-ROW,22-CHAR	806976	1	
DS2	TUBE,DISPLAY,VAC FLUOR,256X26	832543	1	
H1	LABEL,C-MOS INSTRUCTION	464016	1	
J2	HEADER,2 ROW,.100CTR,40 PIN	807453	1	
M1-10	FOOT,RUBBER,ADHES,BLK,.50 SQ,.12 THK	543488	10	
Q1-4,Q7-10	* TRANSISTOR,SI,PNP,50V,350MW,SOT-23	742023	8	
Q5,Q6,Q11,Q12	* TRANSISTOR,SI,NPN,50V,350MW,SOT-23	742031	4	
R1,R3,R5,R6,R8, R10-12,R20,R28- R30,R55-59,R61, R63,R65,R72, R76	* RES,CERM,4.7K,+-5%,.125W,200PPM,1206 * * * *	740522 740522 740522 740522	22	
R2,R4,R7,R9, R40,R41,R52, R53	* RES,CERM,1.1K,+-5%,.125W,200PPM,1206 * *	746008 746008 746008	8	
R13-15,R24,R25, R70,R73-75	* RES,CERM,39K,+-5%,.125W,200PPM,1206 *	746677 746677	9	
R16-19	* RES,CERM,150,+-1%,.125W,100PPM,1206	772780	4	
R22,R26,R39, R42,R51,R54	* RES,CERM,6.8K,+-5%,.125W,200PPM,1206 *	746024 746024	6	
R23,R27,R71	* RES,CERM,82K,+-5%,.125W,200PPM,1206	811794	3	
R31-34,R43-46, R60,R62,R64, R66	* RES,CERM,1K,+-5%,.125W,200PPM,1206 * *	745992 745992 745992	12	
R35,R36,R68	* RES,CERM,620,+-5%,.125W,200PPM,1206	745984	3	
R37,R38	* RES,CERM,470,+-5%,.125W,200PPM,1206	740506	2	
R47,R48	* RES,CERM,453,+-1%,.125W,100PPM,1206	801415	2	
R49,R50	* RES,CERM,1.5K,+-5%,.125W,200PPM,1206	746438	2	
R67	* RES,CERM,200,+-5%,.125W,200PPM,1206	746339	1	
R77	* RES,CERM,91,+-5%,.125W,200PPM,1206	756338	1	
R81,R82	* RES,CERM,10,+-5%,1W,200PPM,2512	886705	2	
R83	* RES,CERM,200,+-5%,.5W,200PPM,2010	886952	1	
SP1	AF TRANSD,PIEZO,22 MM	602490	1	
U1,U2	* IC,NMOS,1K X 8 DUAL PORT SRAM,PLCC	806653	2	
U3	* IC,CMOS,PLD,PROGRAMD,5700A-90720,PLCC	838607	1	
U4	* IC,CMOS,PLD,PROGRAMD,5700A-90721,PLCC	838615	1	
U5	* IC,CMOS,PLD,PROGRAMD,5700A-90722,PLCC	845375	1	
U6	* IC,CMOS,14 STAGE BINARY COUNTEER,SOIC	831081	1	
U7	* IC,COMPARATOR,DUAL,HIGH SPEED,SOIC	831271	1	
U8	* IC,CMOS,12 STAGE BIN RIPPLE CNTR,SOIC	831636	1	
U9	* IC,CMOS,PLD,PROGRAMD,5700A-90723,PLCC	845383	1	
U10	* IC,LSTTL,OCTL D TRNSPRNT LATCHES,SOIC	742726	1	
U11	* IC,CMOS,HEX INVERTER,SOIC	742585	1	

Table 6-3. A2 Front Panel PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
U12	* IC,CMOS,DUAL D F/F,+EDG TRG,SOIC	782995	1	
U13	* IC,TTL,HEX INVERTER,W/OPEN COLL,SOIC	741249	1	
U14-23	* IC,BIMOS,DISPLAY DRIVER,80V,PLCC	741231	10	
U24	* IC,CMOS,PLD,PROGRAMD,5700A-90724,PLCC	837369	1	
VR3,VR4	* ZENER,UNCOMP,6.2V,5%,60.5MA,1.5W,SMB	886700	2	
VR5	* ZENER,UNCOMP,5.1V,5%,20MA,0.2W,SOT-23	837179	1	
W1	CABLE, MOTHERBOARD TO DISPLAY	791640	1	

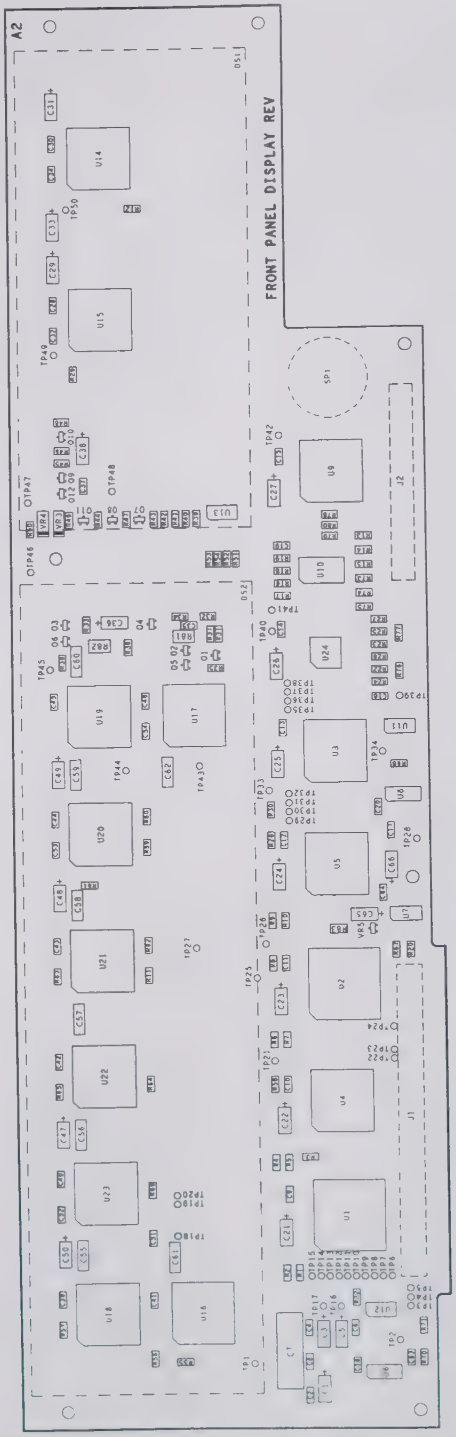

Figure 6-5. A2 Front Panel PCA

Table 6-4. A3 Analog Motherboard PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1	CAP,POLYES,0.1UF,+-10%,50V	649913	1	
C2	CAP,CER,1000PF,+-20%,50V,X7R	697458	1	
C3	CAP,TA,1UF,+-20%,35V	697417	1	
C4	CAP,TA,4.7UF,+-20%,25V	807644	1	
C5	CAP,POLYES,0.47UF,+-10%,50V	697409	1	
CR1,CR2	* DIODE,SI,BV=75V,IO=150MA,500MW	203323	2	
H1,H2	SCREW,PH,P,LOCK,STL,6-32,.250	152140	2	
H3-5	CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	3	
J101,J111,J201,	CONN,DIN41612,TYPE C,64 SCKT	807818	2[illegible]	
J202,J211,J212,		807818		
J301,J302,J311,		807818		
J312,J401,J402,		807818		
J501,J502,J511,		807818		
J512,J601,J602,		807818		
J611,J612,J701,		807818		
J702,J801,J802,		807818		
J901,J902		807818		
J71	FIBER OPTIC,RECEIVER,1MBD	822148	1	
J72	FIBER OPTIC,TRANSMITTER,1MBD	822155	1	
J811,J812,J821,	SOCKET,1 ROW,PWB,.156CTR,10 POS	851183	4	
J822		851183		
K1-3	RELAY,ARMATURE,2 FORM C,4.5VDC	783746	3	
K4,K5,K9, K10	RELAY,REED,1 FORM A,5VDC	806950	4	
K6-8,K11	RELAY,ARMATURE,2 FORM C,5V	733063	4	
K12	RELAY,REED,1 FORM B,5VDC	845164	1	
K13	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307	1	
MP3-54	RIVET,S-TUB,OVAL,AL,.087,.250	838482	52	
MP55,MP56	SPACER,BROACH,.281 RND,STL,6-3	414508	2	
MP57-61	SPACER,BROACH,SNAP,BR,.250	820613	5	
MP62-66	CLAMP,CABLE,ADHESIVE,NYLON,.125	854273	5	
MP101-128	CONN ACC,DIN41612,KEY	832733	28	
R1	RES,CF,75,+-5%,0.25W	441642	1	
R2	RES,CF,91,+-5%,0.25W	441683	1	
RV1	VARISTOR,22V,+-20%,1.0MA	500777	1	
W1	CABLE, FRONT/REAR	802835	1	
W2	CABLE ASSY, MOTHERBOARD BUS, FRONT	859926	1	
W3	CABLE ASSY, MOTHERBOARD BUS, REAR	859934	1	
W8	CABLE, KEYBOARD/REAR PANEL	802710	1	
W11	CABLE, BOOST	802744	1	
XK1-3	RELAY SOCKET,4 POLE	441964	3	

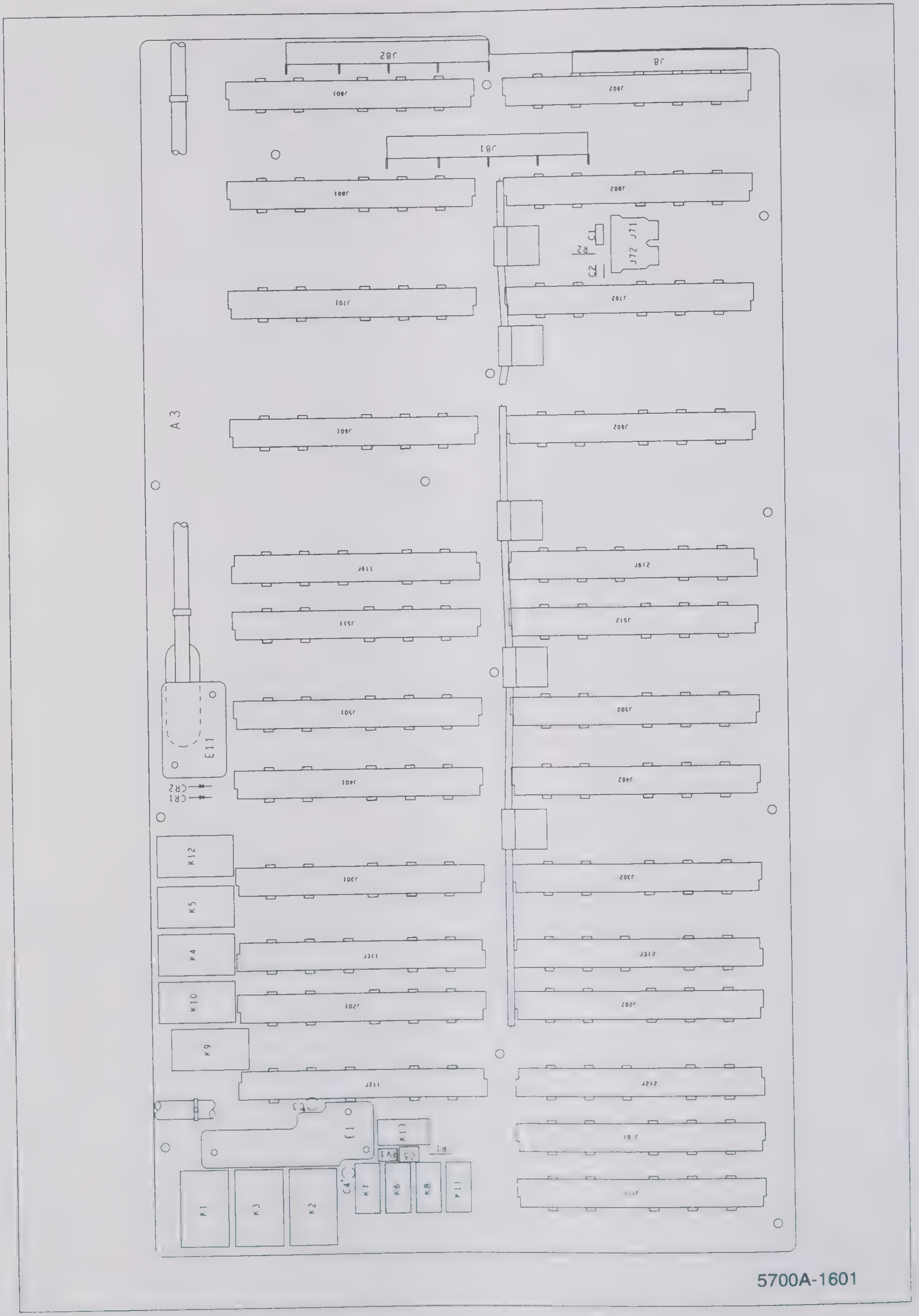

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Figure 6-6. A3 Analog Motherboard PCA

Table 6-5. A4 Digital Motherboard PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C4	CAP,TA,10UF,+-20%,35V	816512	2	
C2	CAP,CER,1000PF,+-20%,50V,X7R	697458	1	
C3	CAP,POLYES,0.1UF,+-10%,50V	649913	1	
C5	CAP,POLYES,0.1UF,+-20%,250VAC	542233	1	
C6	CAP,CER,6800PF,+-5%,100V,C0G	816710	1	
CR3,CR4	DIODE,SI,100 PIV,1.0 AMP	698555	2	
F1	FUSE,.25X1.25,3A,250V,SLOW	109280	1	1
H8-14	CABLE ACCESS,TIE,4.00L,.10W,.75 DIA	172080	7	
H19,H20	SCREW,PH,P,LOCK,SS,4-40,.187	149567	2	
H21,H22	WASHER,FLAT,STL,.093,.219,.020	306415	2	
J11	HEADER,1 ROW,.156CTR,12 PIN	831354	1	
J13	HEADER,1 ROW,.156CTR,10 PIN	446724	1	
J14	HEADER,1 ROW,.156CTR,16 PIN	831370	1	
J15	HEADER,1 ROW,.156CTR,14 PIN	831362	1	
J16	HEADER,1 ROW,.156CTR,8 PIN	385435	1	
J21	CONN,DIN41612,TYPE C,RT ANG,64 PIN	853437	1	
J31	HEADER,1 ROW,.156CTR,RT ANG,5 PIN	844717	1	
J41,J61,J62	CONN,DIN41612,TYPE C,64 SCKT	807818	3	
J51,J52	HEADER,1 ROW,.100CTR,3 PIN	845334	2	
J73	FIBER OPTIC,TRANSMITTER,1MBD	822155	1	
J74	FIBER OPTIC,RECEIVER,1MBD	822148	1	
J91	HEADER,2 ROW,.100CTR,34 PIN	851696	1	
MP1	HLDR PART,FUSE,BODY,PWB MT	602763	1	
MP2	HLDR PART,FUSE,CAP,1/4X1-1/4	460238	1	
MP3-10	RIVET,S-TUB,OVAL,AL,.087,.250	838482	8	
MP11	RIVET,S-TUB,OVAL,AL,.087,.343	838458	2	
MP16	BRACKET, POWER SWITCH	885710	1	
MP17,MP18, MP20	SPACER,SWAGED,.312 RND,BR,.177	837864 837864	3	
MP22,MP23	FOOT,RUBBER,ADHES,GRY,.44 DIA,.20 THK	358341	2	
MP24-26	SPACER,BROACH,SNAP,AL,.187	820639	3	
P81,P82	HEADER,1 ROW,.156CTR,20 PIN	831222	2	
R1	RES,CF,91,+-5%,0.25W	441683	1	
R2,R3	RES,WW,2,+-1%,.7W	255646	2	
R4	RES,CF,68,+-5%,0.25W	414532	1	
RV1	VARISTOR,22V,+-20%,1.0MA	500777	1	
RV2	VARISTOR,430V,+-10%,1.0MA	519355	1	
SW1	SWITCH,PUSHBUTTON,DPST,PUSH-PUSH	886697	1	
SW2-4	SWITCH,SLIDE,DPDT,LINE SELECT,RT ANG	817353	3	
W15	CABLE, FIBER OPTIC	791681	1	
W90	CABLE, REAR PANEL-CPU	791665	1	

1. Fuse PN 109280 is for 100-120 volt configuration. For 200-230 volt configuration order PN 109231.

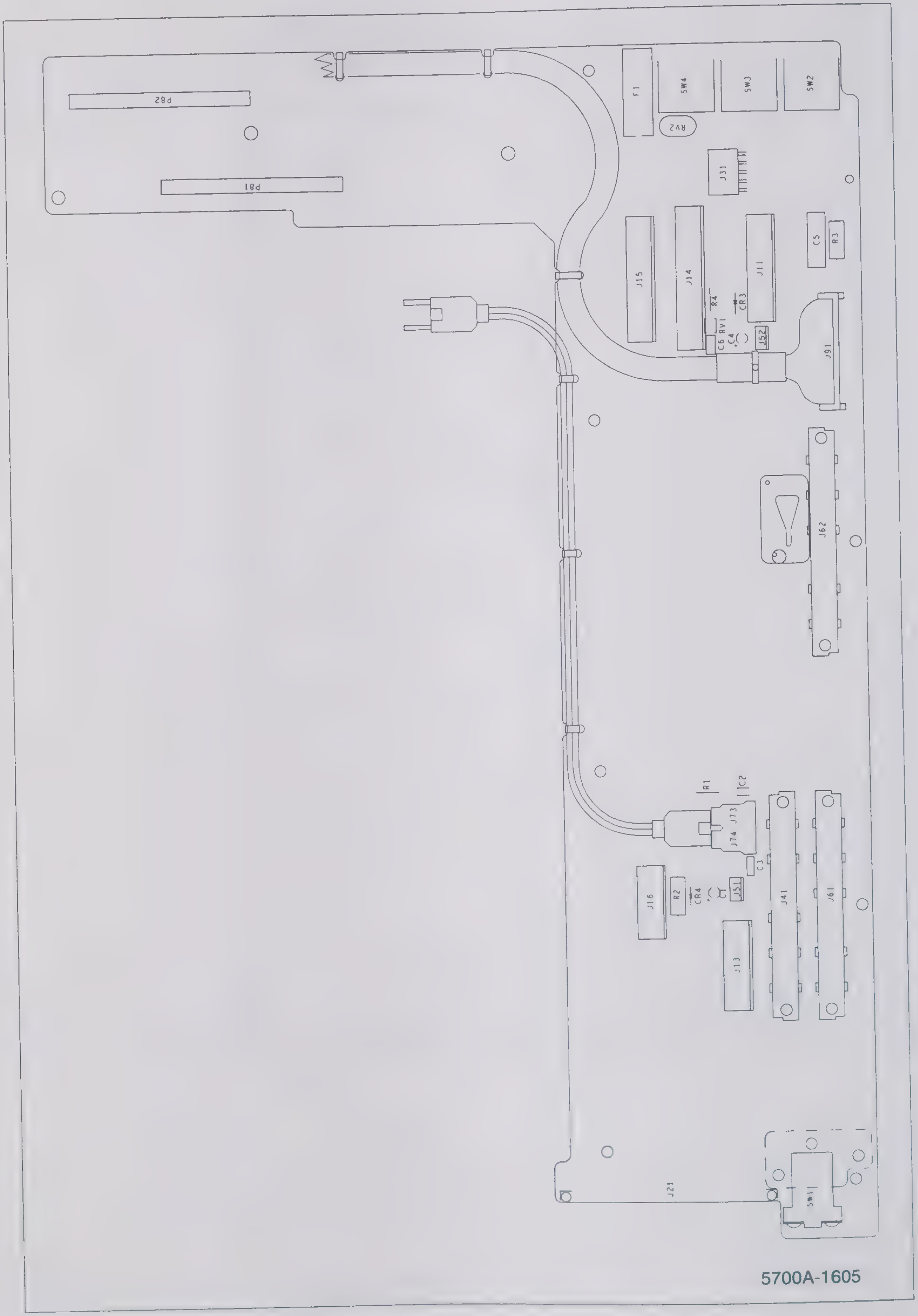

Figure 6-7. A4 Digital Motherboard PCA

Table 6-6. A5 Wideband Output PCA, Option -03

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1	CAP,CER,4.7PF,+-0.25PF,50V,C0G	721837	1	
C2	CAP,CER,22PF,+-2%,50V,C0G	714832	1	
C3	CAP,POLYES,0.047UF,+-10%,50V	820548	1	
C4,C11-13,C66	CAP,CER,100PF,+-5%,50V,C0G	831495	5	
C5	CAP,CER,470PF,+-10%,50V,C0G	733071	1	
C6,C52,C53,C79	CAP,POLYES,0.033UF,+-10%,50V	715276	4	
C14	CAP,POLYES,0.22UF,+-5%,50V	747519	1	
C7,C10,C15,C23, C81	CAP,POLYES,0.47UF,+-10%,50V	697409 697409	5	
C8,C9,C25,C27- 29,C33-37,C45- 51,C55-63,C72- 76,C80	CAP,POLYES,0.1UF,+-10%,50V	649913 649913 649913 649913	34	
C16,C18,C26, C39-44,	CAP,TA,4.7UF,+-20%,25V	807644 807644	9	
C17,C21	CAP,TA,4.7UF,+-20%,25V	807644	2	
C19,C77,C78	CAP,POLYES,0.001UF,+-10%,50V	720938	3	
C20,C22,	CAP,CER,33PF,+-5%,50V,C0G	714543	2	
C38	CAP,CER,5.6PF,+-0.25PF,100V,C0H	512954	1	
C64,C65	CAP,POLYES,1UF,+-10%,50V	733089	2	
C67	CAP,CER,33PF,+-2%,50V,C0G	715292	1	
C68	CAP,CER,18PF,+-2%,100V,C0G	830638	1	
C82	CAP,AL,47UF,+-20%,16V,SOLV PROOF	643304	1	
C83	CAP,CER,270PF,+-5%,50V,C0G	658898	1	
CP1	ADAPTER,BNC(F),BANANA PLUG(M)	528802	1	
CP2	ADAPTER,COAX,BNC(M),N(F)	756775	1	
CP3	POUCH,TEST LEAD	525212	1	
CR1-4,CR6,CR7	* DIODE,SI,BV=75V,IO=150MA,500MW	659516	6	
CR5	* I-REG DIODE,5.3MA,21%,SEL,TO-226AC	852116	1	
E1,E2	WIRE,COPPER/TIN,BUS,22AWG	115469	2	
E3,	JUMPER,REC,2 POS,.100CTR,.025	757294	1	
H1	LABEL,C-MOS INSTRUCTION	464016	1	
H7-9	SCREW,PH,P,LOCK,SS,6-32,.500	320051	4	
H10-19	INSUL PT,TRANSISTOR MOUNT,DAP,TO-5	152207	10	
J1,J2	CONN,COAX,SMB(M),PWB,RT ANG	353243	2	
J3	HEADER,1 ROW,.100CTR,2 PIN	643916	1	
K1,K11	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	2	
K2,K3,K9,K10, K12	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307 769307	5	
K4-8	RELAY,ARMATURE,2 FORM C,5VDC	806810	5	
L1-6,L18	CHOKE,6TURN	320911	7	
L19	INDUCTOR,100UH,+-10%,12MHZ,SHLD	249102	1	
L20-22	INDUCTOR,220UH,+-5%,9.4MHZ,SHLD	147835	3	
L23	CORE,TOROID,FERRITE,.047X.138X.118	321182	1	
M2	SHIELD, WB OUTPUT, REAR	764498	1	
M3	SHIELD, WIDEBAND AMP, FRONT	775643	1	
M4	SHIELD, WB OUTPUT, ATTENUATOR,REAR	775650	1	
M5	SHIELD, WB OUTPUT, ATTENUATOR,FRONT	775668	1	
MP1	TERMINATION,COAX,N(M),N(F),50 OHM	853429	1	
MP2,MP3	* RIVET,S-TUB,OVAL,AL,.087,.343	838458	2	
MP4,MP5	EJECTOR,PWB,NYLON	494724	2	
MP6,MP25-34	SCREW,PH,P,LOCK,STL,6-32,.250	152140	11	
MP10-14	RELAY WASHER	803247	5	
MP15-24	HEAT DIS,PRESS ON,TO-5	418384	10	
P111	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	1	
Q1	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698241	1	

Table 6-6. A5 Wideband Output PCA, Option -03 (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
Q17	* TRANSISTOR,SI,N-JFET,TO-92	816314	1	
Q2,Q03	* TRANSISTOR,SI,N-DMOS FET,TO-72	394122	2	
Q4-6	* TRANSISTOR,SI,NPN,20V,500MW,MACRO-T	659417	3	
Q7,Q08,Q11-13	* TRANSISTOR,SI,PNP,100V,3.5W,TO-39	866769	5	
Q9,Q10,Q14-16	* TRANSISTOR,SI,NPN,100V,3W,T0-39	912522	5	
Q18	* TRANSISTOR,SI,N-DMOS PWR FET,T0-92	782565	1	
R1	RES,MF,866,+-1%,0.125W,50PPM	320390	1	
R2	RES,MF,200,+-1%,0.125W,100PPM	245340	1	
R3	RES,MF,412K,+-1%,0.125W,50PPM	714287	1	
R7,R8	RES,MF,698K,+-1%,0.125W,100PPM	757252	2	
R9,R24,R27,R42, R102	RES,CF,20K,+-5%,0.25W	697110 697110	5	
R10	RES,CF,3M,+-5%,0.25W	746172	1	
R11	RES,MF,20.5K,+-1%,0.125W,100PPM	655233	1	
R12,R111-113	RES,CF,2K,+-5%,0.25W	810457	4	
R13	RES,MF,14.3K,+-1%,0.125W,100PPM	721803	1	
R14,R28,R114	RES,MF,10K,+-1%,0.125W,100PPM	658914	3	
R15,R38	RES,CF,3K,+-5%,0.25W	810366	2	
R16	RES,CF,620,+-5%,0.25W	810408	1	
R17	RES,MF,866,+-1%,0.125W,50PPM	816603	1	
R18	RES,MF,200,+-1%,0.125W,100PPM	820282	1	
R19,	RES,CF,12K,+-5%,0.25W	757799	1	
R20,R31	RES,CF,4.7K,+-5%,0.25W	721571	2	
R21,R104	RES,MF,10.5K,+-1%,0.125W,100PPM	816611	2	
R22,R35	RES,CF,9.1K,+-5%,0.25W	706663	2	
R23	RES,CF,1M,+-5%,0.25W	649970	1	
R25	RES,MF,205K,+-1%,0.125W,100PPM	706234	1	
R26	RES,CF,43K,+-5%,0.25W	821777	1	
R29,R121	RES,MF,56.2K,+-1%,0.125W,100PPM	706242	2	
R30,R103,R105, R106	RES,CF,150K,+-5%,0.25W	758219 758219	4	
R32,R63	RES,CF,10K,+-5%,0.25W	697102	2	
R33	RES,CF,22K,+-5%,0.25W	747535	1	
R34	RES,CF,24K,+-5%,0.25W	697599	1	
R36,R40,R45, R62	RES,CF,1K,+-5%,0.25W	780585 780585	4	
R37	RES,MF,210,+-1%,0.125W,100PPM	327999	1	
R39	RES,CF,16K,+-5%,0.25W	714303	1	
R41	RES,CF,180K,+-5%,0.25W	348946	1	
R43,R44	RES,MF,100,+-0.1%,0.125W,25PPM	357400	2	
R46	RES,MF,1.74K,+-1%,0.125W,100PPM	344358	1	
R47	RES,MF,1K,+-1%,0.125W,100PPM	168229	1	
R48,R49,R51, R55,R61,R65, R71,R76,R77, R84,R85,R90, R91	RES,CF,51,+-5%,0.25W	414540 414540 414540 414540 414540	13	
R50	RES,MF,499,+-1%,,0.125W,100PM	168211	1	
R52	RES,MF,150,+-1%,0.125W,100PPM	448555	1	
R53	RES,MF,402,+-1%,0.125W,100PPM	289611	1	
R54	RES,MF,576,+-1%,0.125W,100PPM	294843	1	
R56,R57	RES,MF,80.6,+-1%,0.5W,100PPM	158790	2	
R58,R59	RES,MF,75,+-1%,0.5W,100PPM	150870	2	
R64	RES,MF,806,+-1%,0.6W,50PPM	851944	1	
R66	RES,MF,49.9,+-1%,0.125W,100PPM	305896	1	
R67,R68	RES,MF,21,+-1%,0.125W,100PPM	296632	2	

Table 6-6. A5 Wideband Output PCA, Option -03 (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
R69,R70	RES,MF,249,+-1%,0.5W,100PPM	241281	2	
R72,R73,R80-83	RES,MF,909,+-1%,0.5W,100PPM	178053	6	
R74	RES,CF,20K,+-5%,0.25W	441477	1	
R75	RES,MF,10K,+-1%,0.125W,100PPM	168260	1	
R78,R79,R86-89	RES,MF,12.7,+-1%,0.125W,100PPM	441766	6	
R92-95	RES,MF,75,+-1%,0.125W,100PPM	306027	4	
R96-99	RES,MF,187,+-0.1%,0.5W,25PPM	807750	4	
R100	RES,MF,1.21K,+-1%,0.125W,100PPM	229146	1	
R101	RES,MF,1.43K,+-1%,0.125W,25PPM	447995	1	
R107	RES,CF,100,+-5%,0.25W	810465	1	
R108	RES,MF,49.9,+-1%,0.125W,100PPM	820266	1	
R109	RES,MF,2.15K,+-1%,0.125W,50PPM	347039	1	
R110	RES,MF,1K,+-0.1%,0.125W,25PPM	340380	1	
R115	RES,CF,200K,+-5%,0.25W	441485	1	
R116	RES,MF,2K,+-1%,0.125W,100PPM	816629	1	
R117	RES,MF,1.69K,+-1%,0.125W,100PPM	321414	1	
R118	RES,CF,1.5K,+-5%,0.25W	810432	1	
R119	RES,MF,8.06K,+-1%,0.125W,100PPM	817619	1	
R120	RES,MF,124,+-1%,0.125W,100PPM	343905	1	
R122	RES,MF,4.99K,+-1%,0.125W,100PPM	721548	1	
R123-128	RES,CF,10,+-5%,0.25W	807669	6	
TP1-19	JUMPER,WIRE,NONINSUL,0.200CTR	816090	19	
U1	* RMS CONVERTER TESTED 400 OHM-B	767707	1	
U2,U12	* IC,OP AMP,DUAL,PRECISION,8-PIN	783696	2	
U3	* IC,ARRAY,5 TRANS,NPN,3 ISO,2 DIFF CON	248906	1	
U4	* IC,COMPARATOR,DUAL,LO-PWR,8 PIN DIP	478354	1	
U5	* IC,OP AMP,LO-OFFSET VOLTAGE,LO-NOISE	605980	1	
U6	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	1	
U7	* IC,CMOS,PROGRMBL PERIPHERAL INTERFACE	780650	1	
U8	* IC,CMOS,8-1 LINE MUX/DEMUX ANALOG SW	836304	1	
U9,U10	* IC,BIMOS,4 CHNL HI-VOLT DRVR W/LATCH	820514	2	
U11	* IC,OP AMP,DUAL,LO OFFST VOLT,LO-DRIFT	851704	1	
VR1	* ZENER,UNCOMP,9.1V,5%,20MA,0.5W	853788	1	
VR2	* ZENER,COMP,6.4V,2%,2PPM,1MA	419036	1	
VR3	* ZENER,UNCOMP,16.0V,5%,15.5MA,1.0W	313221	1	
VR4	* ZENER,UNCOMP,5.6V,5%,20MA,0.5W	820464	1	
W1	CABLE, WIDEBAND OUTPUT INTERCONNECT	802876	1	
W2	CABLE ASSY,50 OHM,COAX,N(M),3FT	853432	1	
Z1	* RNET,CERM,SIP 5700 ATTENUATOR	760728	1	
Z2	* RNET,CERM,SIP,5700 ATTENUATOR	760769	1	

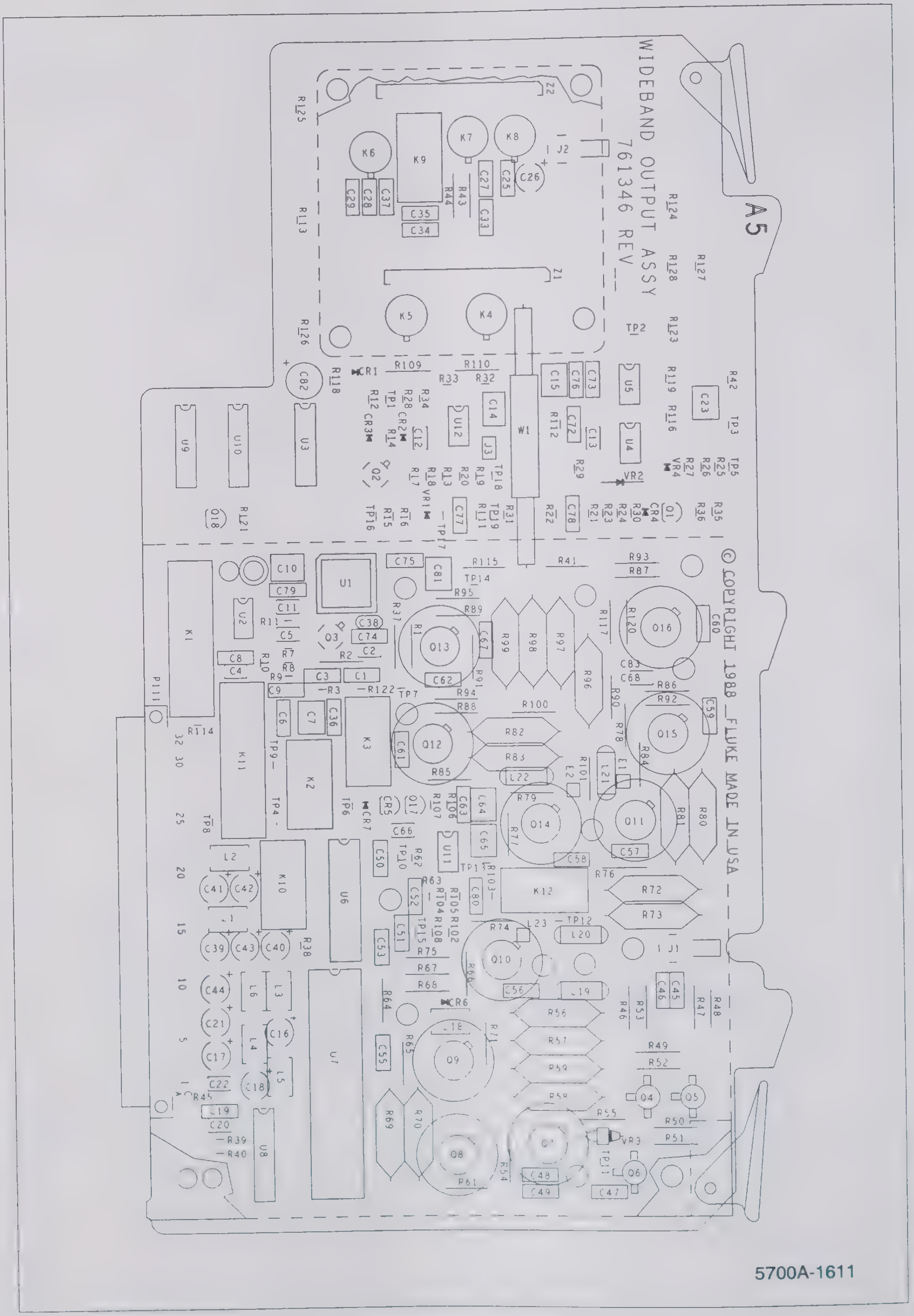

Figure 6-8. A5 Wideband Output PCA, Option -03

Table 6-7. A6 Wideband Ocillator PCA, Option -03

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1-8,C49-51	CAP,TA,4.7UF,+-20%,25V	807644	11	
C9,C10	CAP,CER,2700PF,+-5%,50V,C0G	832303	2	
C11	CAP,CER,15PF,+-20%,50V,C0G	697524	1	
C12,C15,C16,	CAP,POLYES,0.1UF,+-10%,50V	649913	55	
C18-25,C29-33,		649913		
C35-48,C52,		649913		
C57,C58,C60,		649913		
C61,C101,C103,		649913		
C105-107,C201,		649913		
C203,C205-207,		649913		
C301,C303, C305-307,C401,		649913		
C403,C405-407,		649913		
C501,C503,C505-507		649913		
		649913		
		649913		
C13,C14	CAP,CER,0.047UF,+-10%,100V,X7R	844733	2	
C17	CAP,POLYES,0.22UF,+-10%,50V	706028	1	
C26-28	CAP,CER,0.01UF,+-10%,100V,X7R	557587	3	
C34,C209-212	CAP,CER,82PF,+-2%,50V,C0G	714857	5	
C53	CAP,CER,6800PF,+-5%,50V,C0G	542894	1	
C54,C55,C102,	CAP,POLYES,0.001UF,+-10%,50V	720938	12	
C108,C202,C208,		720938		
C302,C308,C402,		720938		
C408,C502,C508		720938		
C56,C59	CAP,CER,33PF,+-5%,50V,C0G	714543	2	
C62,C409-412	CAP,CER,390PF,+-2%,50V,C0G	820530	5	
C109-112	CAP,CER,47PF,+-2%,100V,C0G	832295	4	
C309-312	CAP,CER,180PF,+-2%,50V,C0G	820522	4	
C509-512	CAP,CER,820PF,+-2%,50V,C0G	631002	4	
CR1,CR2	DIODE,SI,VARACTOR,PIV=28V,500PF	598078	2	
CR102,CR103,	* DIODE,SI,SWICHING,PIN	334227	10	
CR202,CR203,	*	334227		
CR302,CR303,	*	334227		
CR402,CR403,	*	334227		
CR502,CR503	*	334227		
CR3-9 CR101,	* DIODE,SI,BV=75V,IO=150MA,500MW	659516	12	
CR201 CR301,	*	659516		
CR401 CR501	*	659516		
E2-5	JUMPER,WIRE,NONINSUL,0.200CTR	816090	4	
E6	JUMPER,REC,2 POS,.100CTR,.025	757294	1	
H6	LABEL,C-MOS INSTRUCTION	464016	1	
H10	SCREW,PH,P,LOCK,SS,6-32,.750	376822	1	
J1	CONN,COAX,SMB(M),PWB,RT ANG	353243	1	
J6	HEADER,1 ROW,.100CTR,2 PIN	643916	1	
L1-4,L7-12,L14,	CHOKE,6TURN	320911	12	
L15		320911		
L5	INDUCTOR,0.20UH,+-10%,400MHZ,SHLD	886809	1	
L6	INDUCTOR,1500UH,+-5%,2.5MHZ,SHLD	806505	1	
L16,L102,L104	INDUCTOR,1UH,+-5%,156MHZ,SHLD	806562	3	
L101,L503	INDUCTOR,22UH,+-10%,38MHZ,SHLD	147843	2	
L103	INDUCTOR,1.5UH,+-5%,128MHZ,SHLD	413856	1	
L201	INDUCTOR,33UH,+-10%,33MHZ,SHLD	249086	1	
L202,L204	INDUCTOR,2.2UH,+-5%,108MHZ,SHLD	806547	2	
L203	INDUCTOR,3.3UH,+-10%,88MHZ,SHLD	174714	1	
L301	INDUCTOR,82UH,+-10%,14MHZ,SHLD	542290	1	
L302,L304	INDUCTOR,3.9UH,+-5%,84MHZ,SHLD	413864	2	
L303	INDUCTOR,5.6UH,+-10%,69MHZ,SHLD	598219	1	
L401	INDUCTOR,120UH,+-5%,11.2MHZ,SHLD	321042	1	
L402,L404	INDUCTOR,8.2UH,+-5%,58MHZ,SHLD	806521	2	

Table 6-7. A6 Wideband Oscillator PCA, Option -03 (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
L403	INDUCTOR,12UH,+-5%,47MHZ,SHLD	820720	1	
L501	INDUCTOR,220UH,+-5%,9.4MHZ,SHLD	147835	1	
L502,L504	INDUCTOR,15UH,+-5%,41MHZ,SHLD	806513	2	
MP1	SHIELD, WIDEBAND OSCILLATOR, FRONT	775478	1	
MP2	SHIELD, WIDEBAND OSCILLATOR, REAR	775486	1	
MP5,MP11,MP12	CABLE ACCESSORY,CLAMP,ADHESIVE	838300	3	
MP6,MP7	RIVET,S-TUB,OVAL,AL,.087,.343	838458	2	
MP8,MP9	EJECTOR,PWB,NYLON	494724	2	
MP10	CABLE, 75 OHM RF	761304	1	
Q2,Q3	TRANSISTOR,SI,NPN,SMALL SIGNAL	698241	2	
Q4-7	* TRANSISTOR,SI,NPN,HI-FREQ,SMALL	659417	4	
Q8,Q9,Q101, Q105,Q201,Q205, Q301,Q305,Q401, Q405 Q501,Q505	* TRANSISTOR,SI,N-DMOS FET,TO-72 * * *	394122 394122 394122 394122	12	
Q102,Q202,Q302, Q402,Q502	* TRANSISTOR,SI,NPN,SM SIGNAL,HI *	272930 272930	5	
Q103,Q104,Q203, Q204,Q303,Q304, Q403,Q404,Q503, Q504	* TRANSISTOR,SI,NPN,SMALL SIGNAL * * *	820407 820407 820407 820407	10	
R3	RES,CF,300K,+-5%,0.25W	732818	1	
R4,R5,R39,R41	RES,CF,12K,+-5%,0.25W	757799	4	
R6,R87	RES,CF,100,+-5%,0.25W	810465	2	
R7	RES,CF,9.1K,+-5%,0.25W	706663	1	
R8,R25-27,R38, R52,R66,R67, R79,R80,R83	RES,CF,1K,+-5%,0.25W	780585 780585 780585	11	
R9	RES,CF,20K,+-5%,0.25W	697110	1	
R11,R12 R15-18, R21,R22	RES,CF,51,+-5%,0.25W	414540 414540	8	
R13,R14,R19, R20,R23,R24, R70	RES,CF,270,+-5%,0.25W	348789 348789 348789	7	
R28-30,R36,R81	RES,CF,2K,+-5%,0.25W	810457	5	
R31	RES,MF,7.32K,+-1%,0.125W,100PPM	853630	1	
R32,R53	RES,MF,1K,+-1%,0.125W,100PPM	816595	2	
R33,R42,R43, R46,R50,R54, R60,R86,R103, R203,R303,R403, R503	RES,MF,49.9,+-1%,0.125W,100PPM	820266 820266 820266 820266 820266	13	
R34,R57	RES,MF,30.1,+-1%,0.125W,100PPM	820563	2	
R35,R55	RES,MF,3.32K,+-1%,0.125W,100PPM	817601	2	
R37	RES,CF,3.9K.+-5%,0.25W	810416	1	
R40,R74-78,R102, R110,R111, R113-116,R202,R210, R211,R213-216, R302,R310,R311, R313,R402,R410, R411,R413,R502, R510,R511, R513	RES,CF,10K,+-5%,0.25W	697102 697102 697102 697102 697102 697102 697102 697102	32	
R44	RES,CF,4.7K,+-5%,0.25W	721571	1	
R45,R47	RES,MF,200,+-1%,0.125W,100PPM	820282	2	
R48	RES,MF,866,+-1%,0.125W,50PPM	816603	1	
R49	RES,MF,10K,+-1%,0.125W,100PPM	658914	1	
R51	RES,MF,4.99K,+-1%,0.125W,100PPM	721548	1	
R56	RES,CC,330,+-5%,0.5W	108936	1	

Table 6-7. A6 Wideband Ocillator PCA, Option -03 (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
R58,R112,R212, R312,R412,R512	RES,MF,110,+-1%,0.125W,100PPM	820571 820571	6	
R59	RES,MF,14.3K,+-1%,0.125W,100PPM	721803	1	
R61	RES,MF,2.49K,+-1%,0.125W,100PPM	810523	1	
R62,R64,R65,R69	RES,CC,680,+-5%,0.5W	178392	4	
R63	RES,CF,200,+-5%,0.25W	810390	1	
R68	RES,MF,1.62K,+-1%,0.125W,100PPM	772004	1	
R71	RES,MF,75,+-1%,0.125W,100PPM	820241	1	
R72,R73	RES,MF,6.65K,+-0.1%,0.125W,100PPM	772558	2	
R82	RES,CF,6.2K,+-5%,0.25W	714337	1	
R84,R85	RES,CF,240,+-5%,0.25W	830588	2	
R101,R201,R301, R401,R501	RES,CC,220,+-5%,0.5W	186031 186031	5	
R104,R204,R304, R404,R504	RES,MF,249,+-1%,0.5W,100PPM	241281 241281	5	
R105,R205,R305, R405,R505	RES,MF,100,+-1%,0.125W,100PPM	817627 817627	5	
R106,R107,R206, R207,R306,R307, R406,R407,R506, R507	RES,CF,130,+-5%,0.25W	817593 817593 817593 817593	10	
R108,R208,R308, R408,R508	RES,MF,523,+-1%,0.125W,100PPM	820274 820274	5	
R109,R209,R309, R409,R509	RES,MF,2.67K,+-1%,0.125W,100PPM	820290 820290	5	
TP1-4,TP10-17	JUMPER,WIRE,NONINSUL,0.200CTR	816090	11	
U1	* IC,CMOS,4-BIT PHASE LCKD LOOP	799452	1	
U2	* IC,OP AMP,JFET INPUT,8 PIN DIP	472779	1	
U3	* IC,ECL,VOLTAGE CONTROLLED OSCILLATOR	454975	1	
U4	* IC,ECL,DUAL D M/S F/F,W/SET&RESET	454959	1	
U5	* IC,ECL,4-BIT BINARY COUNTER,12MHZ	799460	1	
U6	* IC,ECL,8-1 LINE MULTIPLEXER (MUX)	799510	1	
U7,U10,U11	* IC,COMPARATOR,QUAD,14 PIN DIP	387233	3	
U8	* IC,CMOS,BCD-DEC & BIN-OCTAL DC	473769	1	
U9	* IC,PBLR,MONOLITHIC,DIFF. AMP	783738	1	
U12,U13	* IC,ARRAY,5 TRANS,NPN,5 ISOLATE	380188	2	
U14	* IC,CMOS,QUAD INPUT NOR GATE	811158	1	
U15	* IC,COMPARATOR,HI-SPEED,14 PIN	647115	1	
VR1,VR4	* ZENER,UNCOMP,5.1V,5%,20.0MA,0.5W	853700	2	
VR2,VR3	* ZENER,UNCOMP,10.0V,5%,20.0MA,05W	820480	2	
VR5	* ZENER,UNCOMP,6.2V,5%,200MA,5W	806802	1	
Z1	RES,CERM,SIP,10 PIN,9 RES,10K,+-2%	414003	1	
Z2	RES,CERM,SIP,6 PIN,5 RES,10K,+-2%	500876	1	

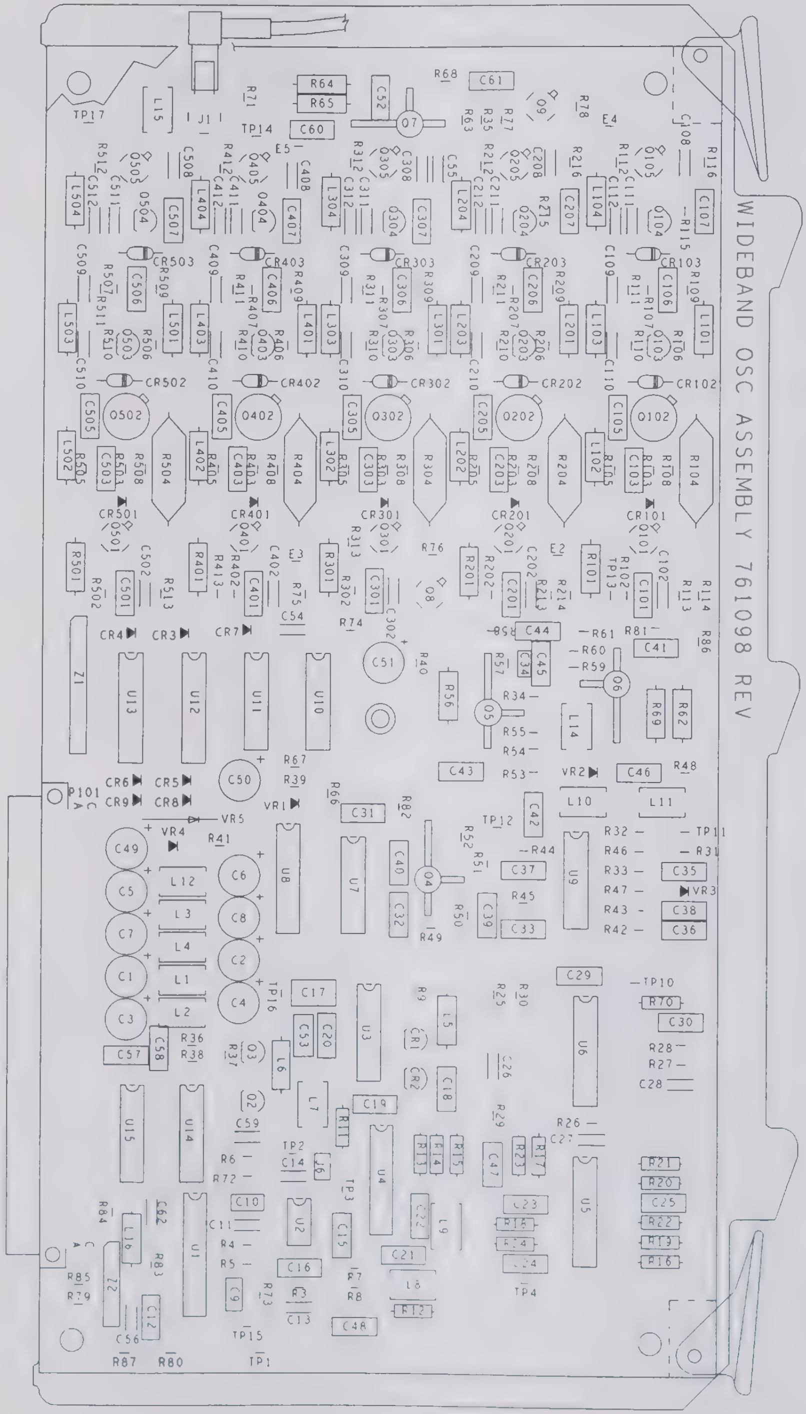

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Figure 6-9. A6 Wideband Oscillator PCA, Option -03

Table 6-8. A7 Current/High-Res Oscillator PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C71	CAP,CER,0.22UF,+80-20%,50V,Z5U	649939	2	
C2,C3,C18-20, C29,C32-35,C47, C48,C50,C51, C55,C56	CAP,POLYES,0.1UF,+-10%,50V	649913 649913 649913 649913	16	
C4,C5	CAP,CER,100PF,+-2%,100V,C0G	812115	2	
C6,C7,C21-24, C37,C38,C40, C43,C52,C53, C60,C61	CAP,TA,4.7UF,+-20%,25V	807644 807644 807644 807644	14	
C8	CAP,CER,18PF,+-2%,100V,C0G	830638	1	
C9	CAP,CER,47PF,+-20%,50V,C0G	706705	1	
C10	CAP,CER,470PF,+-5%,50V,C0G	830430	1	
C11	CAP,CER,4700PF,+-20%,100V,C0G	743427	1	
C12,C13,C70	CAP,AL,47UF,+-20%,50V,SOLV PROOF	822403	3	
C14	CAP,AL,6.8UF,+-20%,35V,SOLV PROOF	643189	1	
C15	CAP,TA,2.2UF,+-20%,16V	706804	1	
C16	CAP,CER,1000PF,+-2%,50V,C0G	807966	1	
C17,C45,C46, C54	CAP,CER,33PF,+-5%,50V,C0G	714543 714543	4	
C25,C26,C30, C36,C41,C42, C49	CAP,POLYES,0.047UF,+-10%,50V	820548 820548 820548	7	
C27,C28	CAP,POLYES,1UF,+-10%,50V	733089	2	
C31,C67	CAP,POLYES,0.22UF,+-5%,50V	747519	2	
C39	CAP,TA,22UF,+-20%,25V	845149	1	
C44	CAP,CER,15PF,+-20%,50V,C0G	697524	1	
C57,C58	CAP,CER,2000PF,+-5%,50V,C0G	832618	2	
C59	CAP,CER,390PF,+-2%,50V,C0G	820530	1	
C62	CAP,CER,820PF,+-2%,50V,C0G	631002	1	
C65,C66	CAP,CER,82PF,+-2%,100V,C0G	512350	2	
C68	CAP,CER,150PF,+-5%,100V,C0G	512988	1	
C69	CAP,CER,27PF,+-2%,100V,C0G	816652	1	
CR1,CR2, CR10, CR11	* DIODE,SI,BV=125V,IO=150MA,500 MW *	844647 844647	4	
CR3,CR4	* DIODE,SI,BV=75V,IO=150MA,500MW	659516	2	
CR9	DIODE,SI,VARACTOR,PIV=28V,500PF	598078	1	
CR12,CR13	DIODE,SI,BV=200V,IO=200MA	876867	2	
E1,E2	JUMPER,WIRE,NONINSUL,0.200CTR	816090	2	
H1-4	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
HR2	* RN/HYBRID CURRENT HYBRID	775387	1	
K1-3,K6 K7,K10-13,K16	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307 769307	10	
K4,K5,K8,K9	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	4	
K14,K15,K17	RELAY,ARMATURE,2 FORM C,5V	733063	3	
L1-3,L5,L7-9	CHOKE,6TURN	320911	7	
L4	INDUCTOR,3.3UH,+-10%,88MHZ,SHLD	174714	1	
L10	INDUCTOR,1UH,+-5%,156MHZ,SHLD	806562	1	
L11	INDUCTOR,150UH,+-5%,10.5MHZ,SHLD	174763	1	
L12	INDUCTOR,6800UH,+-10%,1.5MHZ,SHLD	363184	1	
MP1-5	HEAT DIS,PWB MT,.75X.50X.50,TO-220	816587	5	
MP6	MOLDED COVER, HYBRID, R-NET	775619	1	
MP7,MP8	SHIELD, HIGH RES, FRONT	786442	2	
MP9,MP10	SHIELD, HIGH RES, REAR	786459	2	
MP11,MP12	EJECTOR,PWB,NYLON	494724	2	
P211,P212	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
Q1	* TRANSISTOR,SI,BV=40V,40W,TO-22	369660	1	

Table 6-8. A7 Current/High-Res Oscillator PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
Q2,Q5,Q16,Q18	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698225	4	
Q3,Q4,Q19	* TRANSISTOR,SI,PNP,40V,0.35W,TO-92	698233	3	
Q6,Q7	* TRANSISTOR,SI,BV=80V,10W,TO-20	495689	2	
Q8,Q9	* TRANSISTOR,SI,BV=80V,10W,TO-20	535468	2	
Q10,Q11	* TRANSISTOR,SI,BV=45V,27W,TO-22	325753	2	
Q12,Q13	* TRANSISTOR,SI,BV=55V,30W,TO-22	325761	2	
Q14,Q25	* TRANSISTOR,SI,BV=60V,65W,TO-22	386128	2	
Q15	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698241	1	
Q17	* TRANSISTOR,SI,VMOS,PWR,TO-237,VM10KM	640516	1	
Q20-23	* TRANSISTOR,SI,N-DMOS PWR FET,TO-92	782565	4	
Q24	* TRANSISTOR, SI, BV=60V, 65W, T0-220	559989	1	
R1,R38-40,R44, R54,R55,R61, R62,R65, R78, R91	RES,CF,1K,+-5%,0.25W	780585 780585 780585 780585	12	
R3,R36	RES,CF,4.7K,+-5%,0.25W	721571	2	
R4,R9,R81,R82, R94	RES,MF,1K,+-1%,0.125W,100PPM	816595 816595	5	
R5,R8	RES,CF,62K,+-5%,0.25W	713941	2	
R6,R7	RES,MF,8.87K,+-1%,0.125W,100PPM	658922	2	
R10,R12,R29, R32	RES,MF,8.25K,+-1%,0.125W,100PPM	820357 820357	4	
R11,R13	RES,MF,909,+-1%,0.125W,100PPM	820308	2	
R14	RES,WW,1.2,+-5%,2W	248658	1	
R16	RES,CF,20K,+-5%,0.25W	697110	1	
R17,R37,R50-52	RES,CF,16K,+-5%,0.25W	714303	5	
R18,R89,R95	RES,CF,1.5K,+-5%,0.25W	810432	3	
R19	RES,MF,150,+-1%,0.125W,100PPM	822171	1	
R20-23	RES,MF,162,+-1%,0.125W,100PPM	820340	4	
R24-27	RES,MF,13,+-1%,0.5W,100PPM	820233	4	
R28,R30,R33	RES,MF,10K,+-1%,0.125W,100PPM	658914	3	
R31	RES,MF,4.12K,+-1%,0.125W,100PPM	820381	1	
R34	RES,MF,1.91K,+-1%,0.125W,100PPM	820365	1	
R35,R66,R72, R73,R90	RES,CF,100,+-5%,0.25W	810465 810465	5	
R42	RES,CF,100K,+-5%,0.25W	658963	1	
R43,R60,R67, R68	RES,CF,10K,+-5%,0.25W	697102 697102	4	
R45,R46	RES,CF,33K,+-5%,0.25W	733667	2	
R47,R48	RES,CF,130K,+-5%,0.25W	747436	2	
R49	RES,CF,2.4M,+-5%,0.25W	772566	1	
R53	RES,CF,9.1K,+-5%,0.25W	706663	1	
R56,R57	RES,CC,470,+-10%,1W	109710	2	
R58	RES,CF,620,+-5%,0.25W	810408	1	
R59,R63,R93	RES,CF,3K,+-5%,0.25W	810366	3	
R64	RES,MF,10,+-1%,0.125W,100PPM	820399	1	
R70	RES,MF,100,+-1%,0.125W,100PPM	817627	1	
R71	RES,MF,7.32K,+-1%,0.125W,100PPM	853630	1	
R74,R75	RES,CF,47,+-5%,0.25W	822189	2	
R76,R77,R92	RES,CF,240,+-5%,0.25W	830588	3	
R79,R80	RES,MF,787,+-1%,0.125W,100PPM	853627	2	
R83,R84	RES,CF,330,+-5%,0.25W	830596	2	
R85,R86	RES,WW,27,+-5%,2W	844563	2	
R87,R88	RES,CF,51K+-5%,0.25W	747550	2	
R96,R97	RES,MF,200,+-1%,0.125W,100PPM	820282	2	
RT1,RT2	THERMISTOR,DISC,4.85,25C	838102	2	

Table 6-8. A7 Current/High-Res Oscillator PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
TP1-5,TP7-13, TP16-20	JUMPER,WIRE,NONINSUL,0.200CTR	816090 816090	17	
U2,U3	* IC,OP AMP,PRECISION,LOW NOISE	782920	2	
U4,U22	* IC,OP AMP,JFET INPUT,22V SUPPLY,DIP	832584	2	
U5,U18	* IC,CMOS,QUAD BILATERAL SWITCH	910708	2	
U6,U20	* IC,OP AMP,DUAL,PRECISION,8-PIN	783696	2	
U7	* IC,CMOS,PROGRMBL PERIPHERAL INTERFACE	780650	1	
U8-10	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	3	
U11	* IC,BIMOS,4 CHNL HI-VOLT DRVR W/LATCH	820514	1	
U12	* IC,CMOS,8-1 LINE MUX/DEMUX ANALOG SW	836304	1	
U13	* IC,COMPARATOR,HI-SPEED,14 PIN	647115	1	
U14	* IC,CMOS,DUAL D F/F,+EDG TRG,W/CLR	741702	1	
U15	* IC,CMOS,QUAD INPUT NOR GATE	811158	1	
U16	* IC,CMOS,4-BIT PHASE LCKD LOOP	799452	1	
U17	* IC,CMOS,4-BIT PHASE LCKD LOOP	820506	1	
U19	* IC,ECL,VOLTAGE CONTROLLED OSCILLATOR	454975	1	
U21	* IC,LSTTL,DUAL D F/F,+EDG TRG,W/CLR	393124	1	
VR3	* ZENER,UNCOMP,5.6V,5%,20MA,0.5W	820464	1	
Z1	* RNET,MF,HERM,SIP,5700 LO V DIVIDER	760835	1	
Z2	RES,CERM,SIP,6 PIN,5 RES,10K,+-2%	500876	1	
Z3,Z4	RNET,MF,POLY,SIP,1752 LO V DIVIDER	645341	2	

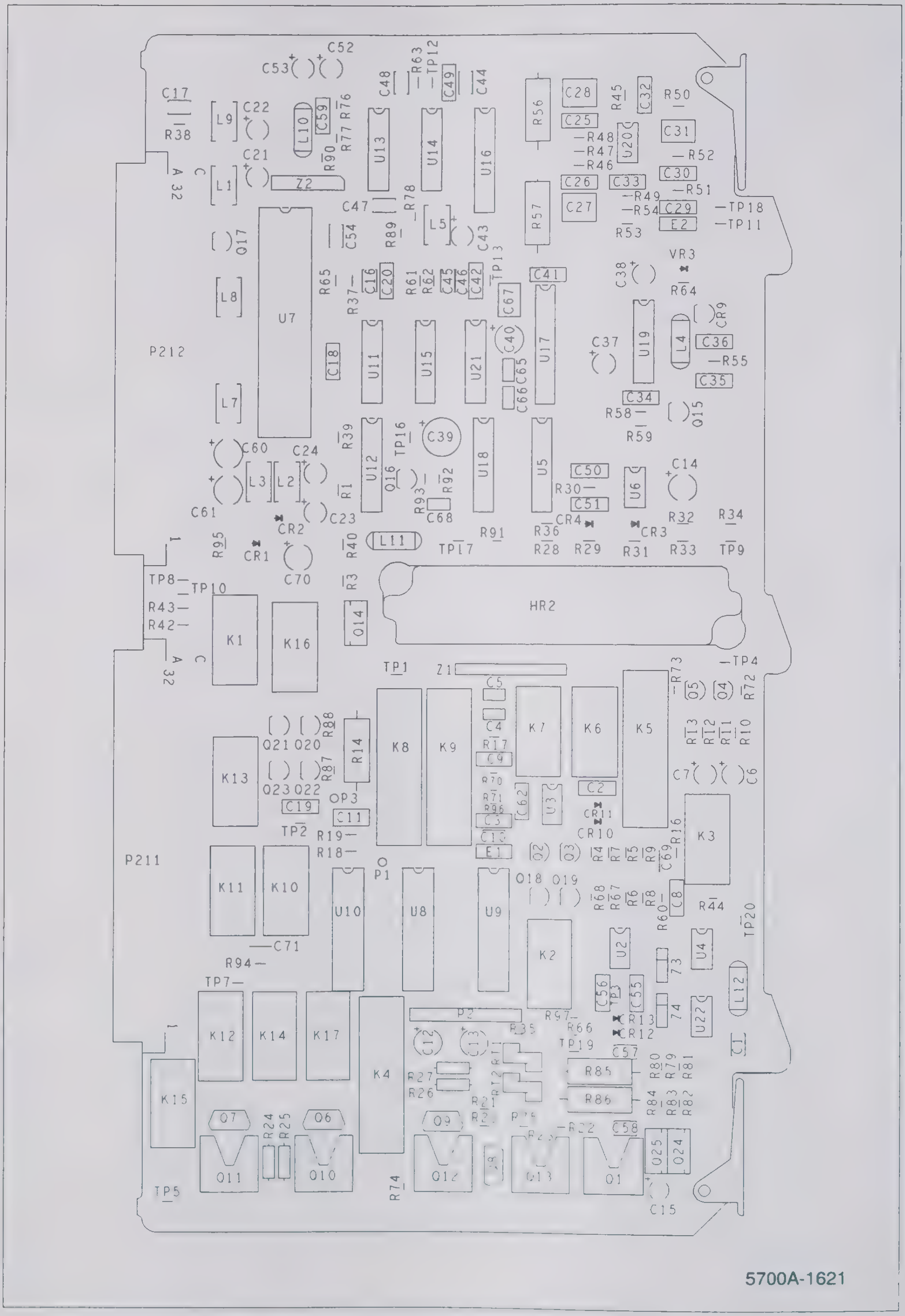

Figure 6-10. A7 Current/High-Res Oscillator PCA

Table 6-9. A8 Switch Matrix PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C3,C18	CAP,CER,470PF,+-10%,50V,C0G	733071	3	
C2,C5	CAP,CER,33PF,+-5%,50V,C0G	714543	2	
C4	CAP,CER,0.01UF,+80-20%,50V,Z5V	697284	1	
C6-9,C12 C13, C15,C16 C21, C25-27	CAP,POLYES,0.22UF,+-5%,50V	747519 747519 747519	12	
C10,C29	CAP,CER,100PF,+-20%,50V,C0G	721605	2	
C14	CAP,CER,15PF,+-2%,100V,C0G	832287	1	
C17	CAP,POLYES,1UF,+-10%,50V	733089	1	
C20	CAP,CER,1000PF,+-20%,50V,X7R	697458	1	
C22	CAP,TA,15UF,+-20%,20V	807610	1	
C23	CAP,CER,22PF,+-2%,50V,C0G	714832	1	
C30	CAP,CER,330PF,+-5%,50V,C0G	697441	1	
C31	CAP,POLYES,0.1UF,+-10%,50V	649913	1	
CR1,CR3,CR4, CR7-9	* DIODE,SI,BV=75V,IO=150MA,500MW *	659516 659516	6	
CR2,CR10	DIODE,SI,100 PIV,1.0 AMP	698555	2	
CR5,CR6,CR12, CR13	* DIODE,SI,BV=125V,IO=150MA,500 MW *	844647 844647	4	
CR14,CR15	DIODE,SI,100 PIV,1 AMP	820449	2	
H2	HYBRID ASSEMBLY, TESTED	813436	1	
H5-8	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
K1,K3-6 K13, K15-20, K22, K24,K25	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078 715078 715078	15	
K2,K7-12,K14, K21,K23 K26-33	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307 769307	18	
L1-4	CHOKE,6TURN	320911	4	
MP2	MOLDED COVER, HYBRID, R-NET	775619	1	
MP9,MP10	EJECTOR,PWB,NYLON	494724	2	
MP18-21	SPACER,.156 RND,SOLUBLE,.062,.060	296319	8	
P201,P202	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
Q1	* TRANSISTOR,SI,BV=60V,65W,TO-22	386128	1	
Q2	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698225	1	
Q4	* TRANSISTOR,SI,PNP,40V,0.35W,TO-92	698233	1	
Q6,Q7,Q11	* TRANSISTOR,SI,N-DMOS PWR FET,T0-92	782565	3	
Q9,Q10	* TRANSISTOR,SI,N-JFET,TO92	845073	2	
Q12,Q13	* TRANSISTOR,SI,N-JFET,HI-VOLTAG	832147	2	
R1	RES,MF,15.4K,+-1%,0.125W,100PPM	772038	1	
R2	RES,MF,1.21K,+-1%,0.125W,100PPM	810507	1	
R3,R4,R6	RES,CF,10K,+-5%,0.25W	697102	3	
R5,R7,R10,R19, R34	RES,MF,1K,+-1%,0.125W,100PPM	816595 816595	5	
R8	RES,MF,12.7K,+-1%,0.125W,25PPM	817510	1	
R9,R46,R47	RES,MF,10K,+-0.1%,0.125W,50PPM	733972	3	
R11,R20,R35	RES,CF,560,+-5%,0.25W	810440	3	
R12	RES,CF,1.5,+-5%,0.25W	732800	1	
R13	RES,CF,330,+-5%,0.25W	830596	1	
R14	RES,CF,4.7K,+-5%,0.25W	721571	1	
R15-17,R21	RES,CF,100K,+-5%,0.25W	658963	4	
R18,R33,R44	RES,MF,20K,+-0.1%,0.25W,25PPM	810564	3	
R22	RES,CF,1K,+-5%,0.25W	780585	1	
R23,R39,R40	RES,CF,100,+-5%,0.25W	810465	3	
R24	1/4 WATT HERM. W.W. RESISTOR	864207	1	
R25	RES,CF,6.2K,+-5%,0.25W	714337	1	
R26	RES,CF,9.1K,+-5%,0.25W	706663	1	

Table 6-9. A8 Switch Matrix PCA (cont)

Reference Designator		Description	Fluke Stock No	Tot Qty	Notes
R27,R28		RES,CF,620,+-5%,0.25W	810408	2	
R29,R30		RES,MF,14.3,+-1%,0.125W,100PPM	831396	2	
R32		RES,MF,10,+-1%,0.125W,100PPM	820399	1	
R36,R37		RES,MF,4.99K,+-1%,0.125W,100PPM	721548	2	
R38		RES,CC,47,+-5%,0.125W	512061	1	
R41,R42		RES,CF,20,+-5%,0.25W	810382	2	
R43		RES,MF,150,+-1%,0.125W,100PPM	822171	1	
T1		MV COMMON MODE CHOKE	802751	1	
TP1-10		JUMPER,WIRE,NONINSUL,0.200CTR	816090	10	
U1	*	IC,CMOS,PROGRMBL PERIPHERAL INTERFACE	780650	1	
U2	*	IC,CMOS,BCD-DEC & BINRY-OCTALTAL DECODER	650689	1	
U3	*	IC,BPLR,FAHRENHEIT TEMPERTURE SENSOR	845156	1	
U4	*	IC,CMOS,8-1 LINE MUX/DEMUX ANALOG SW	836304	1	
U5-13	*	IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	9	
U15	*	IC,COMPARATOR,DUAL,LO-PWR,8 PIN	478354	1	
U17	*	IC,OP AMP,GEN PURPOSE,COMPEMSATED	402750	1	
U19	*	IC,ARRAY,5 TRANS,5 ISO: 2-PNP,3-NPN	418954	1	
U20	*	IC,OP AMP,PRECISION,LOW NOISE	782920	1	
U21	*	IC,OP AMP,LO-OFFSET VOLTAGE,LO-NOISE	605980	1	
VR1,VR2	*	ZENER,UNCOMP,6.8V,5%,20.0MA,0.4W	820431	2	
VR3,VR4	*	ZENER,UNCOMP,5.1V,5%,20.0MA,0.5W	853700	2	
Z1		RNET,MF,HERM,SIP,5700 LO V DIVIDER	759647	1	
Z2	*	RNET,MF,POLY,SIP,8840 LO V DIVIDER	655811	1	
Z3,Z4		RES,CERM,SIP,6 PIN,5 RES,330,+-2%	408302	2	
Z5		RES,CERM,SIP,8 PIN,4 RES,10K,+-2%	513309	1	
Z6		RES,CERM,SIP,6 PIN,5 RES,1K,+-2%	408310	1	

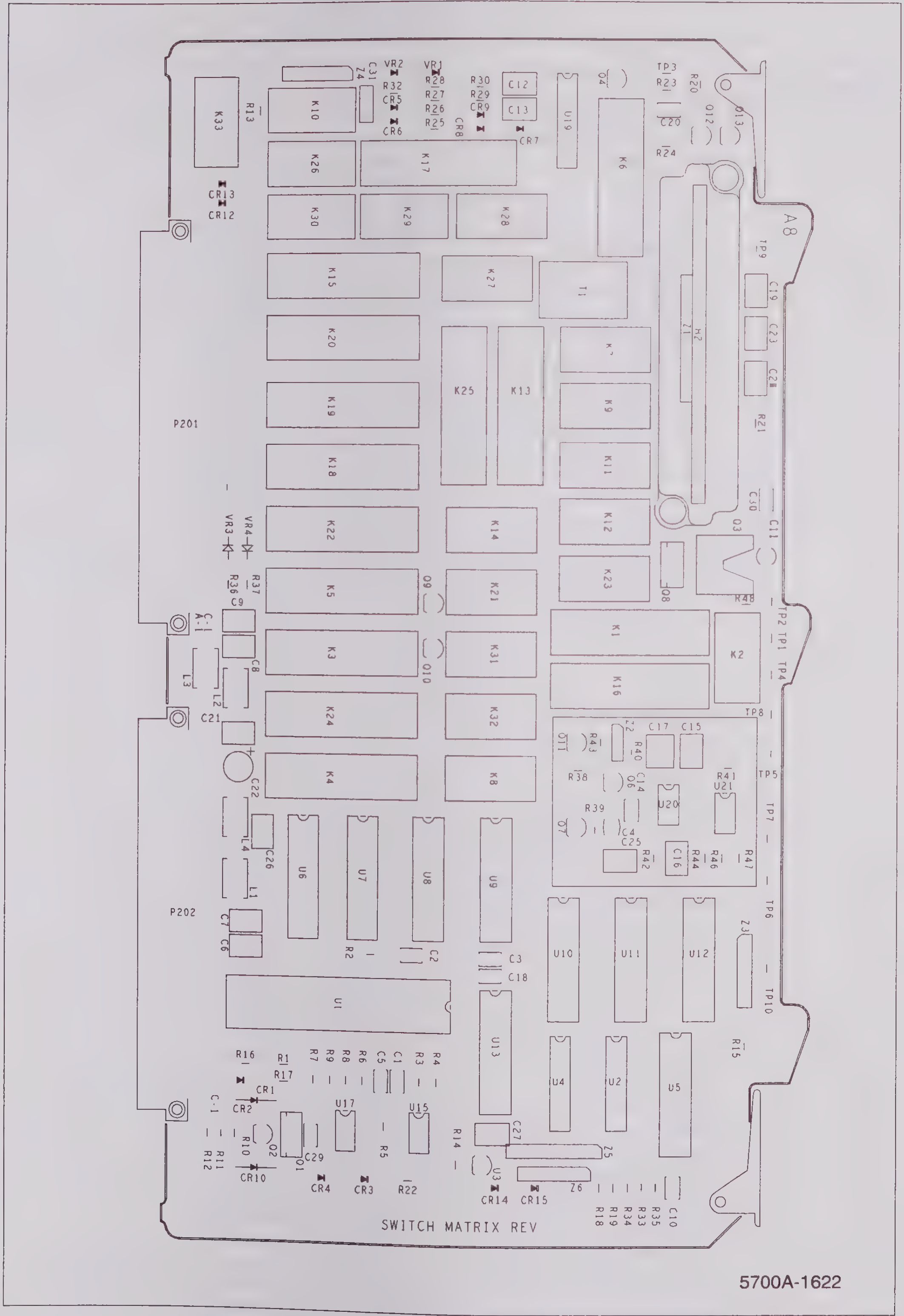

Figure 6-11. A8 Switch Matrix PCA

Table 6-10. A9 Ohms Cal PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C28,C29 C55	CAP,POLYES,0.1UF,+-10%,50V	649913	4	
C2,C3,C32,C35	CAP,CER,1000PF,+-20%,100V,X7R	816181	4	
C4,C5,C8,C10, C14,C15,C31, C37-43 C45	CAP,POLYES,0.22UF,+-5%,50V	747519 747519 747519	15	
C6	CAP,CER,470PF,+-10%,50V,C0G	733071	1	
C7,C9,C22 C23	CAP,TA,2.2UF,+-10%,35V	697433	4	
C12,C13	CAP,CER,220PF,+-20%,50V,C0G	740654	2	
C16,C17	CAP,CER,22PF,+-5%,50V,C0G	714550	2	
C18,C33	CAP,TA,4.7UF,+-20%,25V	807644	2	
C19,C24,C25	CAP,TA,10UF,+-20%,35V	816512	3	
C20,C52	CAP,CER,0.22UF,+80-20%,50V,Z5U	649939	2	
C21	CAP,CER,2700PF,+-5%,50V,C0G	832303	1	
C26,C27	CAP,CER,1800PF,+-5%,50V,C0G	832717	2	
C30	CAP,POLYPR,0.1UF,+-10%,160V	446781	1	
C34,C51	CAP,CER,33PF,+-5%,50V,C0G	714543	2	
C36	CAP,TA,47UF,+-20%,10V	733246	1	
C48	CAP,POLYPR,0.47UF,+-10%,160V	446807	1	
C53,C54	CAP,POLYES,1UF,+-10%,50V	733089	2	
CR1-10	* DIODE,SI,BV=75V,IO=150MA,500MW	659516	10	
H1-4	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
H5	SCREW,PH,P,LOCK,STL,6-32,.250	152140	1	
K1-5,K10 K11, K13 K15-18,K20, K22-27,K31	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307 769307 769307	20	
K6-9,K12 K14, K19,K21 K28-30	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078 715078	11	
L2-8	CHOKE,6TURN	320911	7	
M4	SHIELD, OHMS CAL	786517	1	
MP1,MP2	EJECTOR,PWB,NYLON	494724	2	
MP3	SLEEV,PVC,.500ID,CLEAR	113761	1	
MP4	SHIELD, HIGH VOLTAGE CONTROL	786616	1	
MP6-17	SPACER,.156 RND,SOLUBLE,.062,.060	296319	12	
P311,P312	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
Q1	* TRANSISTOR,SI,BV=60V,65W,TO-22	386128	1	
Q2-4	* TRANSISTOR,SI,VMOS,PWR,TO-237,UV10KM	640516	3	
Q5	* TRANSISTOR,SI,PNP,40V,0.35W,TO-92	698233	1	
Q6	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698225	1	
R1-3,R80	RES,CF,10K,+-5%,0.25W	697102	4	
R4,R8,R13,R32, R35,R39 R45	RES,CF,1K,+-5%,0.25W	780585 780585	7	
R9,R10,R43 R44	RES,CF,47,+-5%,0.25W	822189	4	
R11	RES,CC,330,+-5%,1W	163394	1	
R12,R23	RES,CF,100K,+-5%,0.25W	658963	2	
R14,R15	RES,CF,24,+-5%,0.25W	817528	2	
R16,R17	RES,MF,10K,+-0.1%,0.125W,100PPM	658955	2	
R18	RES,MF,76K,+-0.1%,0.125W,50PPM	851332	1	
R24,R31	RES,CF,22K,+-5%,0.25W	747535	2	
R25	RES,CC,150,+-5%,1W	178566	1	
R26,R46	RES,CF,100,+-5%,0.25W	810465	2	
R27	RES,MF,10K,+-1%,0.125W,100PPM	658914	1	
R29,R30	RES,CF,200,+-5%,0.25W	810390	2	
R33	RES,CF,16K,+-5%,0.25W	714303	1	
R41	RES. SET,1.0 OHM 0.04% 3PPM TC	824193	1	
R42	RES. SET,1.9 OHM 0.04% 3PPM TC	824201	1	
T1	TRANSFORMER, OHMS 2W COMP	802652	1	

Table 6-10. A9 Ohms Cal PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
TP1,TP2,TP5-20	JUMPER,WIRE,NONINSUL,0.200CTR	816090	18	
U1-3	* IC,OP AMP,LO-OFFSET VOLTAGE,LO-NOISE	605980	3	
U4	* IC,OP AMP,PRECISION,LOW NOISE	782920	1	
U5	* IC,OP AMP,GEN PURPOSE,COMPEMSATED	402750	1	
U6	* IC,BIPOLAR,REG PULSE WIDTH MODULATOR	811935	1	
U7	* IC,OP AMP,CHOPPER STABLIZED,LOW NOISE	810952	1	
U8,U9	* IC,OP AMP,LO-NOISE,8 PIN DIP	495051	2	
U10	* IC,OP AMP,DUAL,JFET INPUT,8 PIN	854059	1	
U11	* IC,CMOS,PROGRMBL PERIPHERAL INTERFACE	780650	1	
U12	* IC,CMOS,BCD-DEC & BINRY-OCTAL DECODER	650689	1	
U13	* IC,CMOS,3-8 LINE DCDR W/ENABLE	773036	1	
U14-20	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	7	
U21	* IC,CMOS,8-1 LINE MUX/DEMUX ANALOG SW	836304	1	
U22	* IC,CMOS,HEX INVERTER,UNBUFFERED	741199	1	
VR1,VR2	* ZENER,UNCOMP,8.2V,5%,20MA,0.4W	810309	2	
VR3	* ZENER,UNCOMP,3.3V,5%,20.0MA,0.4W	820423	1	
Z1	* RNET,CERM,SIP,5700 LO V INST AMP	813659	1	
Z2	* RNET,CERM,SIP,5700 LO V AMP GAIN	809368	1	
Z3	RES,CERM,SIP,10 PIN,5 RES,10K,+-2%	529990	1	
Z4	RES,CERM,SIP,6 PIN,5 RES,1K,+-2%	408310	1	
Z5	RNET,MF,HERM,SIP,5700 LO V DIVIDER	915889	1	

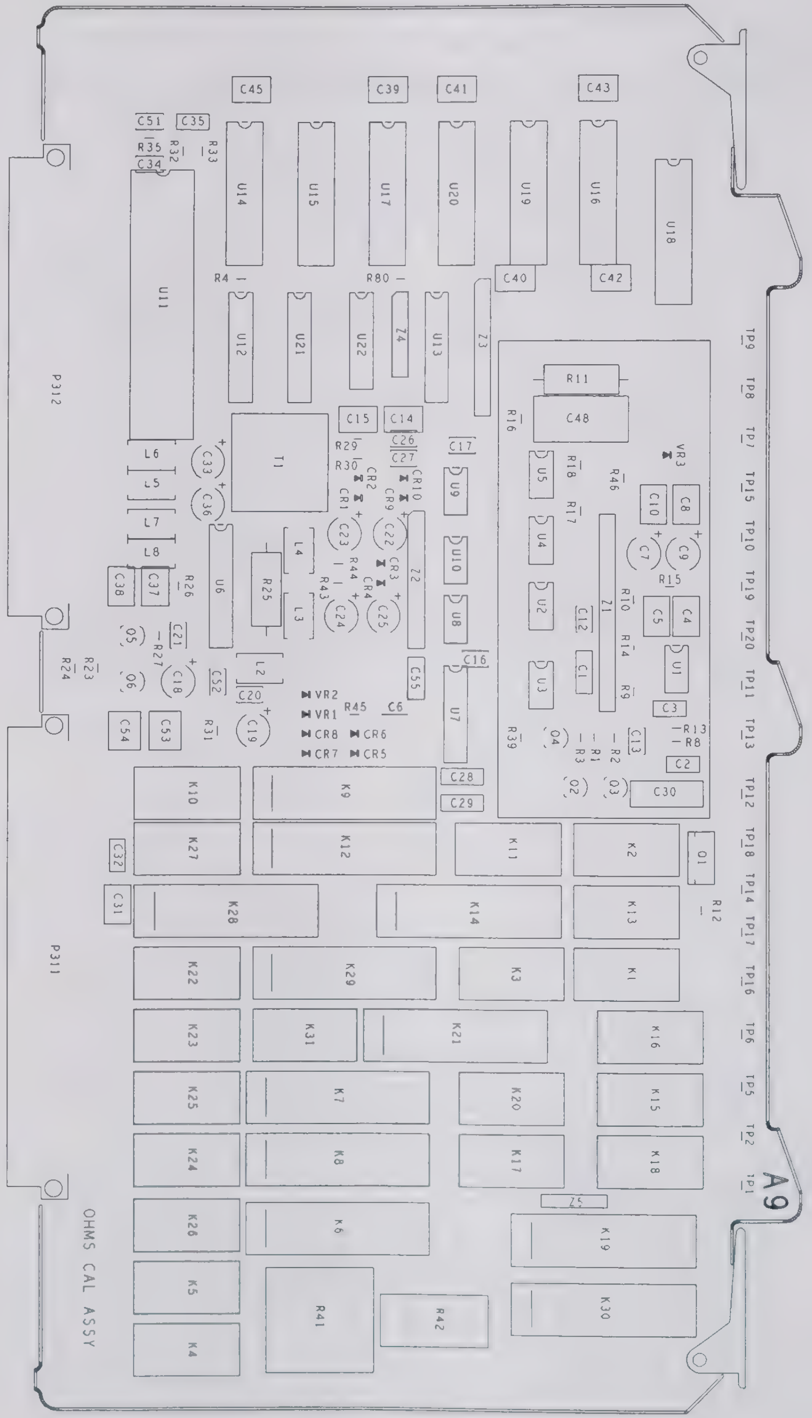

Figure 6-12. A9 Ohms Cal PCA

Table 6-11. A10 Ohms Main PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C2,C7 C10-13,C16	CAP,POLYES,0.22UF,+-5%,50V	747519 747519	8	
C3,C4	CAP,TA,10UF,+-20%,35V	816512	2	
C6	CAP,TA,4.7UF,+-20%,25V	807644	1	
H3-6	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
H7,H8	SCREW,PH,P,LOCK,STL,6-32,.250	152140	2	
K1-4,K7,K9,K10, K13-17,K28-30, K33-37	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307 769307 769307	20	
K5	RELAY,REED,1 FORM A,5VDC	806950	1	
K6,K8,K11,K12	RELAY,REED,1 FORM A,4.5VDC	544031	4	
K18-27,K31 K32, K39	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078 715078	13	
K38	RELAY,ARMATURE,2 FORM C,5V	733063	1	
L4,L5	CHOKE,6TURN	320911	2	
MP1,MP2	SPACER,SWAGE,.250 RND,BR,6-32,.875	266486	2	
MP3,MP4	EJECTOR,PWB,NYLON	494724	2	
MP6	FOOT,RUBBER,ADHES,BLK,.50 SQ,.12 THK	543488	1	
MP7	* OHMS, MAIN, HEAT SHIELD	872325	1	
P301,P302	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
R1	R-NET, THIN FILM, TESTED, FRIT	103306	1	
R2,R3	RES,CF,270,+-5%,0.25W	810424	2	
R5	RES,CF,100,+-5%,0.25W	810465	1	
R6	RES,MF,110K,+-1%,0.125W,100PPM	234708	1	
TP1-5	JUMPER,WIRE,NONINSUL,0.200CTR	816090	5	
U1	* IC,OP AMP,JFET INPUT,LOW NOISE	807933	1	
U2,U3 U5-8, U11-13	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH *	782912 782912	9	
U9	* IC,CMOS,BCD-DEC & BINRY-OCTAL DECODER	650689	1	
U10	* IC,CMOS,3-8 LINE DCDR W/ENABLE	773036	1	
VR1	* ZENER,UNCOMP,3.3V,5%,20.0MA,0.4W	820423	1	
Z1	* RNET,MF,HERM,SIP,5700 RESISTANCE REF	798330	1	
Z2	* RNET,MF,HERM,SIP,5700 RESISTANCE REF	759753	1	
Z3	* RNET,MF,HERM,SIP,5700 RESISTANCE REF	759803	1	

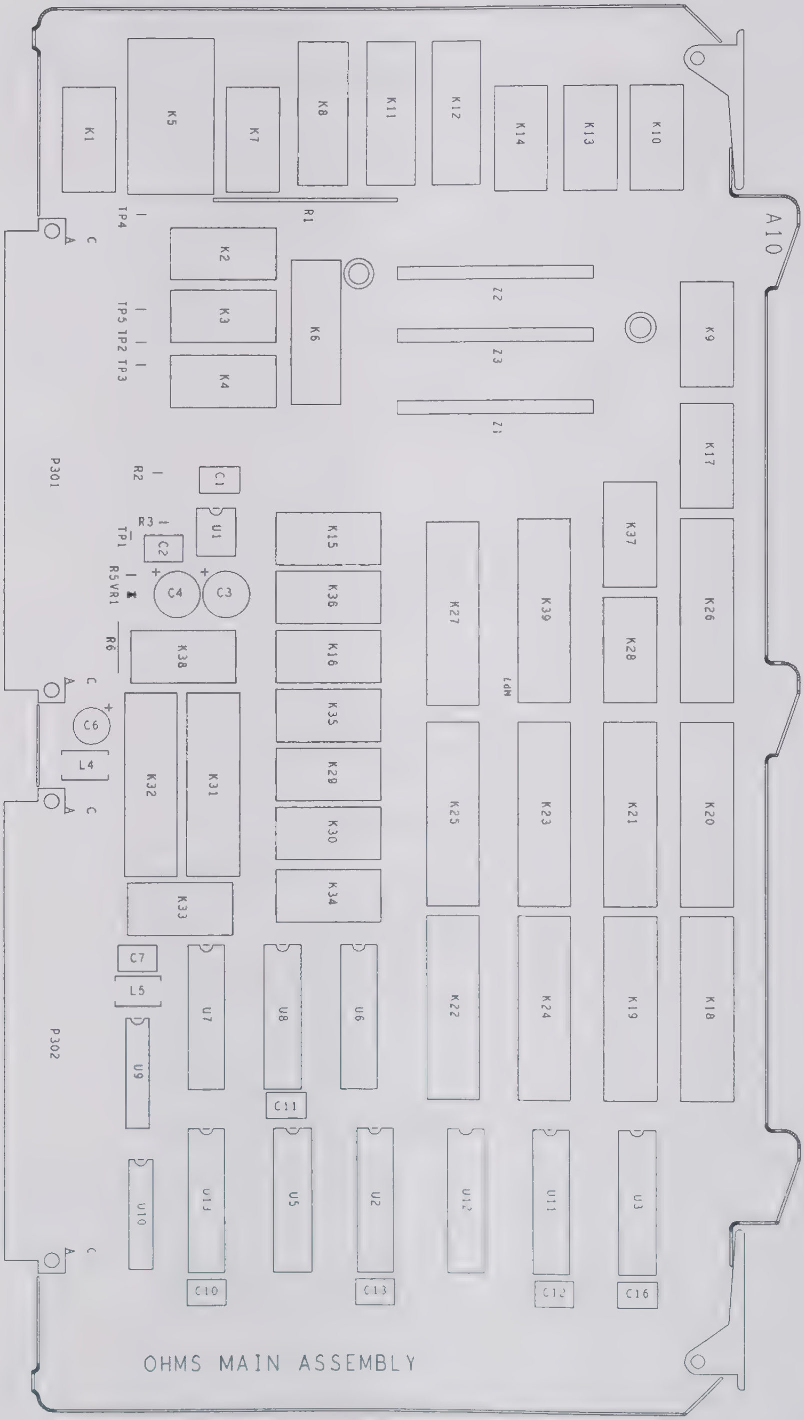

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Figure 6-13. A10 Ohms Main PCA

Table 6-12. A11 DAC PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
A1	DAC FILTER SIP PCA	761395	1	
A2	* DAC BUFFERED REFERENCE SIP PCA	764639	1	
C1,C2,C4-8,C10, C11,C13-18, C21, C23-26, C41,C42 C46-49,C53-56, C58,C62,C64, C65,C76,C77, C81,C86-88, C91, C92,C96-98,C100 C104-109	CAP,CER,0.22UF,+80-20%,50V,Y5V	740597 740597 740597 740597 740597 740597 740597 740597 740597	52	
C3	CAP,CER,3300PF,+-10%,25V,X7R,0805	602870	1	
C9,C12	CAP,AL,10UF,+-20%,63V,SOLV PROOF	816843	2	
C19,C20	CAP,TA,2.2UF,+-10%,35V	697433	2	
C27	CAP,CER,15PF,+-20%,50V,C0G	697524	1	
C29	CAP,CER,220PF,+-2%,100V,C0G	816728	1	
C30,C31	CAP,TA,1.5UF,+-20%,50V,6032	929302	2	
C32	CAP,CER,0.1UF,+-10%,25V,X7R,1206	747287	1	
C40,C80	CAP,CER,47PF,+-10%,50V,C0G,12006	747352	2	
C43	CAP,CER,0.01UF,+-10%,50V,X7R,1206	747261	1	
C44,C60,C63 C94, C102	CAP,CER,1000PF,+-10%,50V,C0G,1206	747378 747378	5	
C45,C89,C95	CAP,POLYPR,0.1UF,+-10%,160V	446781	3	
C52,C101,C103	CAP,CER,33PF,+-10%,50V,C0G,1206	769240	3	
C57,C85	CAP,CER,22PF,+-5%,50V,C0G	714550	2	
C59,C67	CAP,CER,100PF,+-10%,50V,C0G,1206	740571	2	
C78	CAP,POLYES,0.47UF,+-10%,50V	697409	1	
C79	CAP,CER,10PF,+-10%,100V,C0G,1206	806943	1	
C84	CAP,POLYPR,0.022UF,+-10%,160V	494948	1	
C90	CAP,POLYPR,0.033UF,+-10%,63V	721050	1	
C93	CAP,CER,330PF,+-5%,50V,C0G	697441	1	
C110,C111	CAP,POLYES,0.22UF,+-10%,50V	706028	2	
CR1,CR3-6,CR8, CR12,CR13	* DIODE,SI,BV=75V,IO=150MA,500MW *	659516 659516	8	
CR2	* DIODE,SI,N-JFET,CURRENT REG,IF	741512	1	
CR7	* DIODE,SI,N-JFET,CURRENT REG,IF	334839	1	
CR9,CR10	* DIODE,SI,BV=75V,IO=250MA,SOT-2	830489	2	
CR14	* DIODE,SI,N-JFET,CURRENT REG,IF	852116	1	
H1	SCREW,PH,P,LOCK,SS,6-32,.500	320051	1	
H9-12	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
H21	SCREW,PH,P,LOCK,STL,4-40,.187	129882	1	
H26	NUT,HEX,STL,4-40	184044	1	
H28	TERM,RING 5/64 & .144,SOLDR	101055	1	
H32	SHIELD, DAC, FRONT	786483	1	
HR5	* REFERENCE HYBRID ASSY	893334	1	
HR6	* DC AMP HYBRID ASSY	761411	1	
K1,K2,K4	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	3	
K8	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307	5	
L1-7,L10	CHOKE,6TURN	320911	8	
M2	SHIELD, DAC-ADC AMP	786509	1	
M3	SHIELD, DAC, REAR	786491	1	
MP1	MOLDED COVER, HYBRID, R-NET	775619	1	
MP2,MP3	SPACER,SWAGE,.250 RND,BR,6-32,.875	266486	2	
MP5,MP6	EJECTOR,PWB,NYLON	494724	2	
MP7-9	HEAT DIS,PWB MT,.75X.50X.50,TO-220	816587	3	
MP10	HEAT DIS,VERT,.75X.52X.50,TO-220	811760	1	
MP11	SHIELD, DAC, FRONT, SMALL	786434	1	

Table 6-12. A11 DAC PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
MP31	MOLDED COVER, REF. HYBRID	797746	1	
P401,P402	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
Q1	* TRANSISTOR,SI,BV=60V,65W,TO-220	386128	1	
Q2,Q3	* TRANSISTOR,SI,BV=40V,40W,TO-220	369660	2	
Q4-7,Q11,Q22, Q25,Q26	* TRANSISTOR,SI,N-DMOS PWR FET,T0-92 *	782565 782565	8	
Q8	* TRANSISTOR,SI,PNP,SMALL SIG,SE	380394	1	
Q9	* TRANSISTOR,SI,BV=60V,65W,TO-220	386128	1	
Q10,Q19,Q56	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698225	3	
Q12,Q13,Q16, Q17,Q23,Q24	* TRANSISTOR,SI,N-JFET,HI-VOLTAG *	832147 832147	6	
Q14,Q15,Q18, Q20,Q21,Q52, Q53	* TRANSISTOR,SI,N-CHAN,TO-92,SWI * *	832139 832139 832139	7	
Q30,Q32	* TRANSISTOR,SI,N-JFET,SOT-23	844584	2	
Q31,Q33,Q35	* TRANSISTOR,SI,NPN,SMALL SIGNAL	806463	3	
Q34	* TRANSISTOR,SI,PNP,SMALL SIGNAL	838516	1	
Q57	* TRANSISTOR,SI,PNP,40V,0.35W,TO-92	698233	1	
R1,R28,R33,R39, R44,R83 R84	* RES,CERM,4.7K,+-5%,.125W,200PPM *	740522 740522	7	
R2	RES,CF,3K,+-5%,0.25W	810366	1	
R3	RES,CF,2K,+-5%,0.25W	441469	1	
R6	* RES,CERM,910,+-5%,.125W,200PPM	769257	1	
R7	* RES,CERM,620,+-5%,.125W,200PPM	745984	1	
R9,R107,R108	* RES,CERM,1.8K,+-5%,.125W,200PPM	746453	3	
R10	RES,MF,2.49K,+-1%,0.125W,100PPM	810523	1	
R12	* RES,CERM,200,+-5%,.125W,200PPM	746339	1	
R13	* RES,CERM,22,+-5%,.125W,200PPM	746230	1	
R14	RES,MF,61.9M,+-1%,0.25W,150PPM	851741	1	
R15	RES,MF,1.21K,+-1%,0.125W,100PPM	810507	1	
R16	* RES,CERM,750,+-5%,.125W,200PPM	746404	1	
R19-21,R29,R31, R41,R48	* RES,CERM,10K,+-5%,.125W,200PPM *	746610 746610	10	
R22	RES,CF,20K,+-5%,0.25W	697110	1	
R23,R32	* RES,CERM,10,+-5%,.125W,200PPM	746214	2	
R24	* RES,CERM,2.49K,+-1%,.125W,100PPM	806448	1	
R25	* RES,CERM,51.1,+-1%,.125W,100PPM	806422	1	
R26,R27,R70,R89, R90	RES,MF,20K,+-0.1%,0.25W,25PPM	810564 810564	5	
R30,R50,R85	* RES,CERM,510,+-5%,.125W,200PPM	746388	3	
R36,R77,R78, R103,R105	* RES,CERM,1.2K,+-5%,.125W,200PPM *	746412 746412	5	
R37,R106,R110	* RES,CERM,12,+-5%,.125W,200PPM	845458	3	
R38,R49	* RES,CERM,270,+-5%,.125W,200PPM	746354	2	
R40	* RES,CERM,100K,+-5%,.125W,200PPM	740548	1	
R43,R52,R109	* RES,CERM,3K,+-5%,.125W,200PPM	746511	3	
R45	* RES,CERM,2.7K,+-5%,.125W,200PPM	746503	1	
R46	* RES,CERM,360,+-5%,.125W,200PPM	783290	1	
R47,R60,R62,R66, R75,R76	* RES,CERM,100,+-5%,.125W,200PPM *	746297 746297	6	
R51	* RES,CERM,150,+-1%,.125W,100PPM	772780	1	
R53,R71	* RES,CERM,5.1K,+-5%,.125W,200PPM	746560	2	
R58,R59,R64, R73,R124-127	* RES,CERM,56K,+-5%,.125W,200PPM *	746701 746701	8	
R61	RES,CF,1.5K,+-5%,0.25W	810432	1	
R63,R65,R95, R96,R99	* RES,CERM,1K,+-5%,.125W,200PPM *	745992 745992	5	

Table 6-12. A11 DAC PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
R68	RES,MF,40K,+-0.1%,0.125W,100PPM	821702	1	
R69	RES,MF,18.12K,+-0.1%,0.125W,50PPM	734020	1	
R72	RES,CF,200,+-5%,0.25W	810390	1	
R74	* RES,CERM,470K,+-5%,.125W,200PPM	746792	1	
R79-81	* RES,CERM,100K,+-1%,.125W,100PPM	769802	3	
R82,R115,R116	* RES,CERM,10K,+-5%,.125W,200PPM	746610	0	
R86,R87,R100	* RES,CERM,330,+-5%,.125W,200PPM	746370	3	
R88	RES,MF,50K,+-0.1%,0.25W,25PPM	810580	1	
R91	RES,MF,4.12K,+-1%,0.125W,100PPM	820381	1	
R92,R94	* RES,CERM,2K,+-5%,.125W,200PPM	746461	2	
R93	* RES,CERM,8.06K,+-1%,.125W,100PM	806356	1	
R97,R98,R114	* RES,CERM,22K,+-5%,.125W,200PPM	746651	3	
R104	* RES,CERM,15K,+-5%,.125W,200PPM	746628	1	
R111	RES,CF,33K,+-5%,0.25W	733667	1	
R112,R113	RES,CF,10K,+-5%,0.25W	697102	2	
R117-119,R123	* RES,CERM,7.5K,+-5%,.125W,200PPM	746586	4	
T1	PULSE TRANSFORMER	802892	1	
TP1,TP3 TP8-10, TP12	JUMPER,WIRE,NONINSUL,0.200CTR	816090 816090	6	
U1	* IC,OP AMP,DUAL,LO OFFST VOLT,L0-DRIFT	851704	1	
U2,U20	* IC,OP AMP,DUAL,PRECISION,8-PIN	783696	2	
U5	* IC,OP AMP,POWER,IO=250MA	807917	1	
U6	* IC,CMOS,PROGRMBL INTERVAL TIME	806612	1	
U7	* IC,COMPARATOR,HI-SPEED,PRECISIION	822197	1	
U8	* IC,CMOS,OCTL INV LINE DRVR,SOIC	782938	1	
U9	* IC,CMOS,QUAD 2 INPUT OR GATE,SOIC	783712	1	
U10	* IC,COMPARATOR,HI-SPEED,14 PIN	647115	1	
U11	* IC,OP AMP,SINGLE,LOW NOISE FAST,SOIC	783720	1	
U12,U37	* ISOLATOR,OPTO,LED TO TRANSISTOR	454330	2	
U13	* ISOLATOR, 20 MHZ OPTOCOUPLER	742817	1	
U14	* IC,CMOS,DUAL D F/F,+EDG TRG,SOIC	782995	1	
U15	* IC,CMOS,DUAL MONOSTB MULTIVBRTR,SOIC	806620	1	
U19	* IC,OP AMP,DUAL,PRECISION MATCH	782375	1	
U22	* IC,OP AMP,JFET INPUT,22V SUPPLY,DIP	832584	1	
U23	* IC,DMOS,QUAD ANALOG SWITCH,SOIC	928291	1	
U24	* IC,OP AMP,PRECISION,JFET INPUT	808097	1	
U25	IC,CMOS,RR A/D CONVERTER	715680	1	
U26	* IC,OP AMP,DUAL,LO-NOISE,8 PIN	707976	1	
U27,U28	* IC,OP AMP,DUAL,JFET IN,HIGH SPEED	855069	2	
U29	* IC,OP AMP,JFET INPUT,8 PIN DIP	472779	1	
U31	* IC,CMOS,PROGRAMBL PERIPH INTRF	806604	1	
U32	* IC,CMOS,3-8 LINE DCDR W ENABLE	783019	1	
U33,U34	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	2	
U35,U36	* IC,COMPARATOR,QUAD,14 PIN,SOIC	741561	2	
U38	* IC,OP AMP,JFET INPUT,8 PIN DIP	472779	1	
VR1,VR17,VR21, VR31,VR32	* ZENER,UNCOMP,20.0V,5%, 6.2MA,0.4W	810275 810275	5	
VR2,VR8,VR24	* ZENER,UNCOMP,10.0V,5%,12.5MA,0,4W	810267	3	
VR3	* ZENER,UNCOMP,16.0V,7.8MA,0.4W	822205	1	
VR4	* ZENER,UNCOMP,18.0V,5%,7.0MA,0.4W	810325	1	
VR5,VR19,VR20, VR35,VR36	* ZENER,UNCOMP,3.3V,5%,20.0MA,0.4W *	820423 820423	5	
VR6,VR30	* ZENER,UNCOMP,12.0V,10%,10.5MA,0.4W	741074	2	
VR7,VR16	* ZENER,UNCOMP,22.0V,5%,5.6MA,0.4W	811927	2	
VR10,VR12	* ZENER,UNCOMP,10V,5%,20MA,0.2W,SOT-23	783704	2	
VR11	* ZENER,UNCOMP,10.0V,5%,20.0MA,0.5W	820480	1	

Table 6-12. A11 DAC PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
VR13	* ZENER,UNCOMP,13V,5%,9.5MA,0.5W	820456	1	
VR18,VR22	* ZENER,UNCOMP,15.0V,5%,8.5MA,0.4W	820415	2	
VR25	* ZENER,UNCOMP,3.3V,10%,20.0MA,0.4W	309799	1	
VR26	* ZENER,UNCOMP,3.3V,5%,20MA,0.2W	807008	1	
VR27	* ZENER,UNCOMP,7.5V,5%,20MA,0.2W	837138	1	
VR28	* ZENER,UNCOMP,8.2V,5%,20MA,0.2W	837146	1	
VR29	* ZENER,COMP,6.4V,2%,2PPM,1MA	419036	1	
VR33,VR34	* ZENER,UNCOMP,7.5V,5%,20.0MA,0.4W	810291	2	
X1	SOCKET,IC,40 PIN,DUAL WIPE,RETENTION	756668	1	
Z2	* RNET,MF,POLY,SIP,5700 LO V DIVIDER	890244	1	
Z4	RES,CERM,SIP,10 PIN,5 RES,56K,+-2%	529131	1	
Z5	RES,CERM,SIP,6 PIN,5 RES,510,+-2%	459974	1	
Z8	* RNET,MF,HERM,SIP,5700 LO V INST AMP	809418	1	
Z10	RNET,MF,HERM,SIP,5700 A TO D CONV	833830	1	
Z12	RES,CERM,SIP,6 PIN,5 RES,10K,+-2%	500876	1	

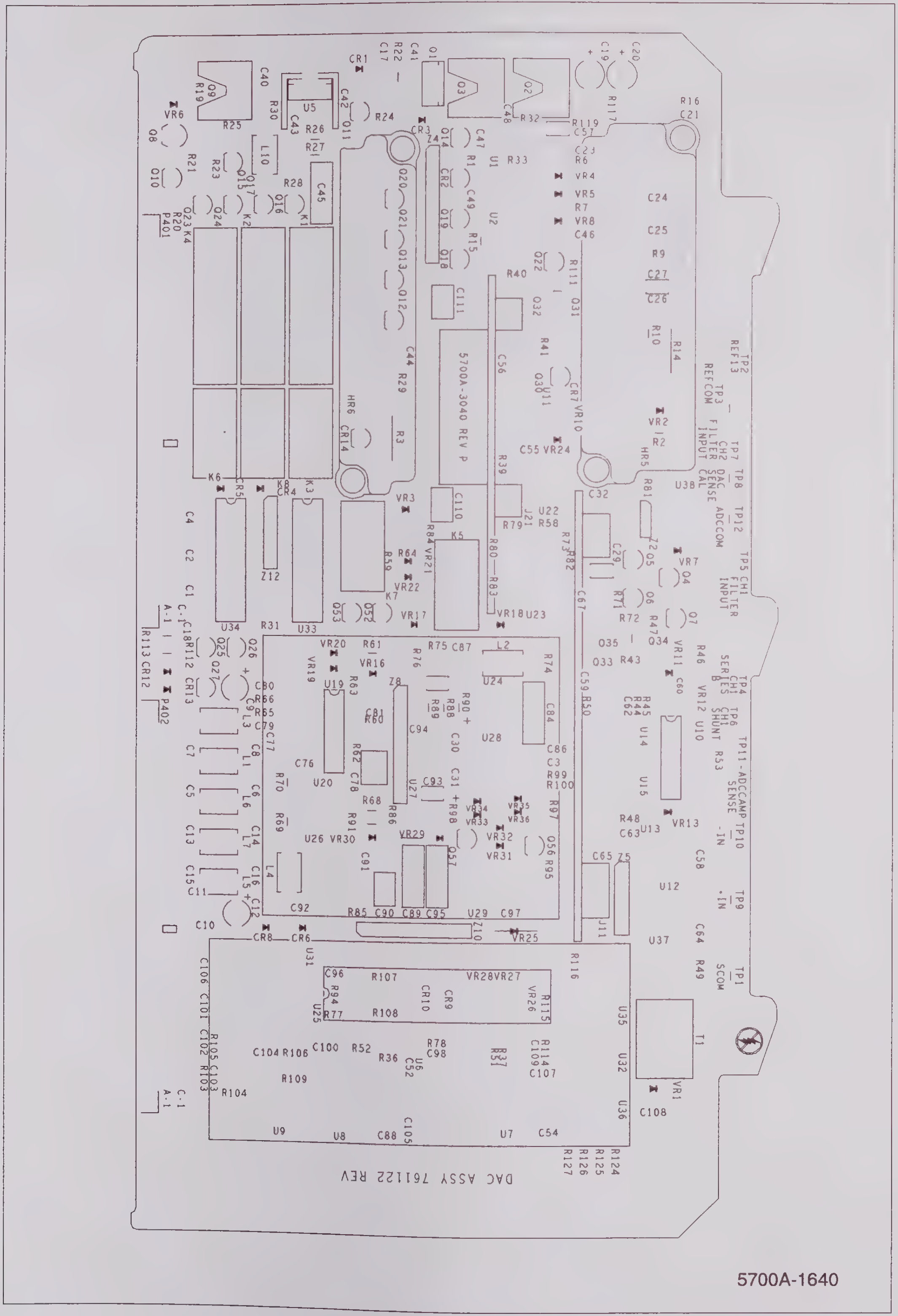

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Figure 6-14. A11 DAC PCA

Table 6-13. A11A1 DAC Filter SIP PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1-6	CAP,POLYES,0.33UF,+-20%,50V	853903	6	
C10,C11	CAP,POLYPR,1UF,+-5%,50V,HERMETIC	783811	2	
C12,C13	CAP,CER,0.22UF,+80-20%,50V,Y5V,1206	740597	2	
C14	CAP,CER,100PF,+-10%,50V,C0G,1206	740571	1	
P21,P22	HEADER,2 ROW,.100CTR,RT ANG,6 PIN	912217	2	
R1,R2	* RES,CERM,11K,+-5%,.125W,250PPM	769752	2	
R3,R5	* RES,CERM,18K,+-5%,.125W,200PPM	746636	2	
R4	* RES,CERM,22K,+-5%,.125W,200PPM	746651	1	
U1	* IC,OP AMP,ULTRA-LOW-NOISE,SOIC	783001	1	
U2	* IC,OP AMP,PRECISION,LOW NOISE	782920	1	
VR1	* ZENER,UNCOMP,15.0V,5%,8.5MA,0.4W	266601	1	

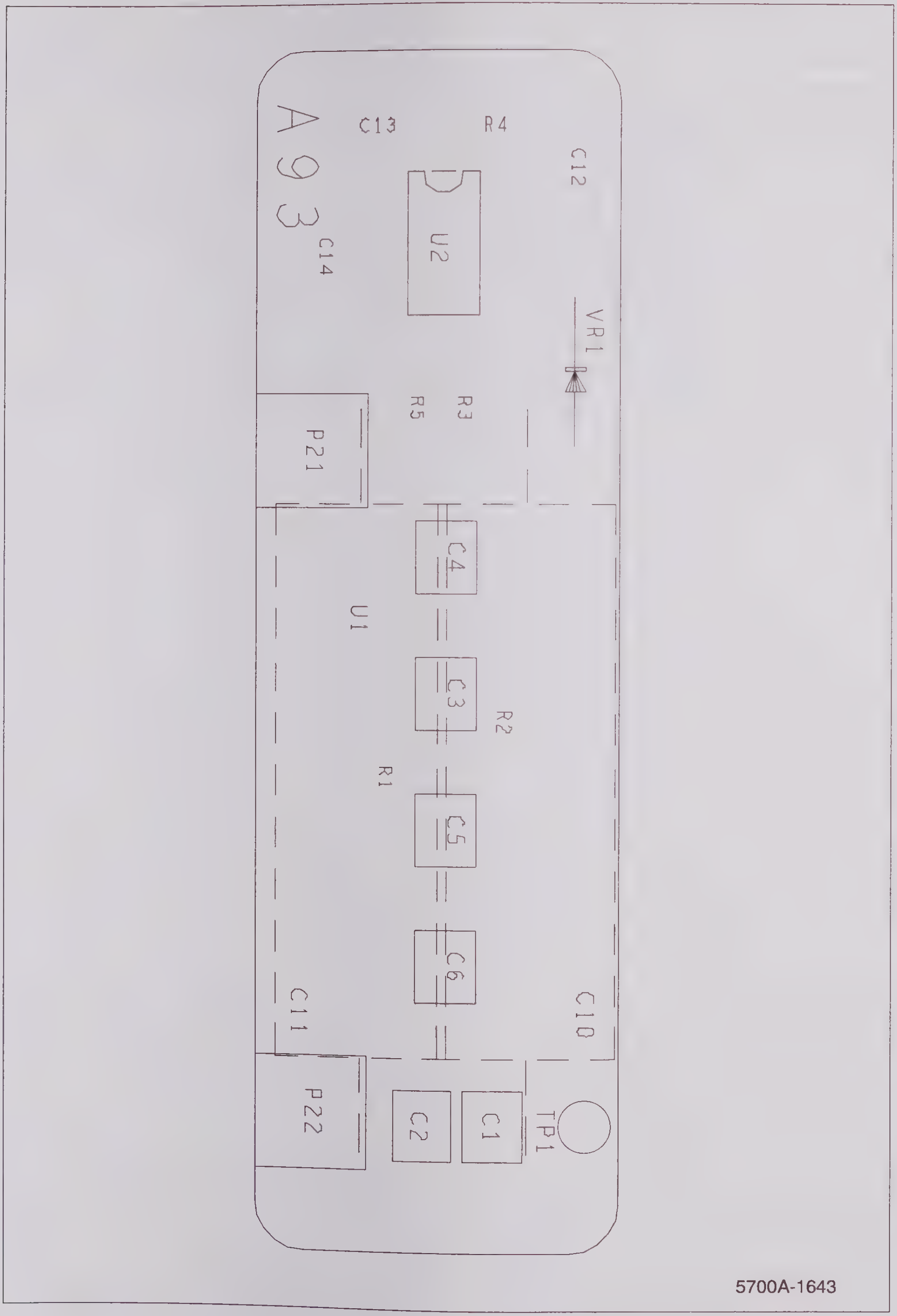

Figure 6-15. A11A1 DAC Filter SIP PCA

Table 6-14. A11A2 DAC Buffered Reference SIP PCA

Reference Designator		Description	Fluke Stock No	Tot Qty	Notes
C1,C5		CAP,CER,10PF,+-10%,100V,C0G,1206	806943	2	
C2,C3		CAP,CER,0.22UF,+80-20%,50V,Y5V	740597	2	
C4,C6		CAP,CER,1000PF,+-10%,50V,C0G,1206	747378	2	
P11		HEADER,2 ROW,.100CTR,RT ANG,10 PIN	658112	1	
P12		HEADER,2 ROW,.100CTR,RT ANG,8 PIN	424200	1	
Q1-15	*	TRANSISTOR,SI,N-JFET,HI-VOLTAG	832147	15	
R1,R6-8	*	RES,CERM,1K,+-5%,.125W,200PPM	745992	4	
R5	*	RES,CERM,10,+-5%,.125W,200PPM	746214	1	
R9	*	RES,CERM,100K,+-1%,.125W,100PPM	769802	1	
U1	*	IC,OP AMP,DUAL,PRECISION,8-PIN	783696	1	
VR1	*	ZENER,UNCOMP,22.0V,5%,5.6MA,0.4W	181073	1	
Z1		RES,CERM,SIP,10 PIN,5 RES,56K,+-2%	529131	1	
Z2		RES,CERM,SIP,6 PIN,5 RES,51K,+-2%	514042	1	

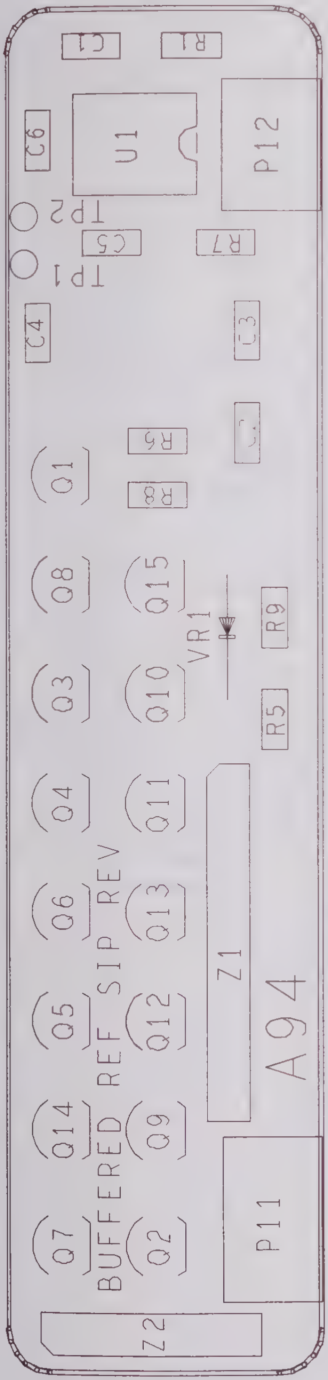

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Figure 6-16. A11A2 DAC Buffered Reference SIP PCA

Table 6-15. A12 Oscillator Control PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1-4,C12 C14, C16,C18 C48	CAP,TA,4.7UF,+-20%,25V	807644 807644	9	
C8,C10	CAP,AL,2.2UF,+-20%,50V	769687	2	
C21	CAP,CER,10PF,+-10%,3000V,C0G	817049	1	
C22,C25	CAP,TA,330UF,+-20%,3V	385963	2	
C23,C24 C36-38,C44-47 C49, C50,C56 C57, C61,C64 C65, C67,C68 C70-72,C76-81	CAP,POLYES,0.22UF,+-5%,50V	747519 747519 747519 747519 747519 747519	27	
C26,C29,C30, C42, C60	CAP,POLYES,0.47UF,+-10%,50V	697409 697409	5	
C27,C28,C31, C43, C63	CAP,POLYES,0.047UF,+-10%,50V	820548 820548	5	
C33,C58,C59	CAP,CER,120PF,+-5%,50V,C0G	721142	3	
C34,C35,C86, C87	CAP,AL,47UF,+-20%,50V,SOLV PROOF	822403 822403	4	
C39,C53	CAP,CER,330PF,+-5%,50V,C0G	697441	2	
C40,C41	CAP,TA,10UF,+-20%,25V	714774	2	
C51,C52,C66	CAP,CER,82PF,+-2%,50V,C0G	714857	3	
C54	CAP,CER,3.3PF,+0.25PF,100V,C0J	816678	1	
C55	CAP,CER,6.8PF,+-0.25PF,50V,C0G	715243	1	
C62	CAP,POLYES,1UF,+-10%,50V	733089	1	
C69,C90,C91	CAP,POLYES,0.01UF,+-10%,50V	715037	3	
C74	CAP,CER,3300PF,+-5%,50V,C0G	830612	1	
C75,C88	CAP,CER,33PF,+-5%,50V,C0G	714543	2	
C82,C85	CAP,POLYES,0.022UF,+-10%,50V	715268	2	
C83	CAP,CER,150PF,+-10%,50V,X7R	682377	1	
C84	CAP,POLYPR,0.47UF,+-10%,160V	446807	1	
CR1-3	* DIODE,SI,BV=75V,IO=150MA,500MW	659516	3	
CR4,CR5	* DIODE,SI,SCHOTTKY BARRIER,SMALL SIGNL	408815	2	
CR6-8	* DIODE,SI,BV=75V,IO=150MA,500MW	203323	3	
CR12-15	* DIODE,SI,BV=70V,500MW	851910	4	
H4-7	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
H13	SCREW,PH,P,LOCK,STL,6-32,.250	152140	1	
HS1	HEAT DIS,RAD,.54X1.25X.35,TO-8	808204	1	
K1	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	1	
K2-9	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307	8	
L1-4	CHOKE,6TURN	320911	4	
MP8,MP9	EJECTOR,PWB,NYLON	494724	2	
M12	OSCILLATOR THERMAL COVER	797696	1	
MP10	SHIELD, HIGH VOLTAGE CONTROL	786616	1	
MP14	SPACER,.375 RND,SOLUBLE,.10THK	837823	1	
P501,P502	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
Q1	* TRANSISTOR,SI,100V,10W,TO-202	943803	1	
Q2	* TRANSISTOR,SI,BV=100V,10W,TO-202	943790	1	
Q3	* TRANSITOR,SI,PNP,SMALL SIG,TO-92	851977	1	
Q4	* TRANSISTOR,SI,NPN SMALL SIGNAL	853478	1	
Q5,Q9,Q11	* TRANSISTOR,SI,N-JFET,TO-92	832162	3	
Q6,Q7,Q12 Q18, Q20	* TRANSISTOR,SI,N-CHAN,TO-92,SWI *	832139 832139	5	
Q8,Q13	* TRANSITOR,SI,N-JFET,UHF/VHF US	851972	2	
Q10	* TRANSISTOR,SI,P-MOS,ZENER PROTECTED	306142	1	
Q14	* TRANSISTOR,SI,NMOS,1W,4 PIN DIVIDER	853692	1	
Q19	* TRANSISTOR,SI,N-DMOS FET,TO-72	394122	1	
R1,R2,R55	RES,CF,30K,+-5%,0.25W	368753	3	

Table 6-15. A12 Oscillator Control PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
R3	RES,MF,143K,+-1%,0.125W,100PPM	291336	1	
R4,R12	RES,CF,3K,+-5%,0.25W	441527	2	
R5,R13,R25 R48, R52,R53 R68, R69	RES,CF,1K,+-5%,0.25W	343426 343426 343426	8	
R6	RES,CF,750,+-5%,0.25W	810374	1	
R7	RES,CF,200,+-5%,0.25W	810390	1	
R8-10	RES,MF,113K,+-1%,0.125W,100PPM	291302	3	
R11	RES,CF,20K,+-5%,0.25W	697110	1	
R14	RES,CF,22K,+-5%,0.25W	348870	1	
R15	RES,CF,5.1K,+-5%,0.25W	368712	1	
R16	RES,CF,15,+-5%,0.25W	348755	1	
R17,R39	RES,CF,510,+-5%,0.25W	441600	2	
R18	RES,CF,47,+-5%,0.25W	822189	1	
R19	RES,CF,10,+-5%,0.25W	807669	1	
R20	RES,MF,301K,+-1%,0.125W,25PPM	379156	1	
R21	RES,CF,2K,+-5%,0.25W	441469	1	
R22,R24,R29, R66	RES,CF,100K,+-5%,0.25W	348920 348920	4	
R23,R30,R33	RES,CF,100K,+-5%,0.25W	658963	3	
R26	RES,MF,316K,+-1%,0.125W,100PPM	289496	1	
R27,R28,R70	RES,CF,1K,+-5%,0.25W	780585	3	
R31,R37,R45	RES,MF,866,+-0.1%,0.125W,50PPM	838441	3	
R32	RES,CF,120,+-5%,0.25W	442293	1	
R34	RES,MF,3.61K,+-0.25%,0.25W,100PPM	832394	1	
R35,R36,R40, R41	RES,MF,649K,+-1%,0.125W,100PPM	375972 375972	4	
R38,R42	RES,MF,357K,+-1%,0.125W,25PPM	312793	2	
R43,R63-65	RES,CF,20K,+-5%,0.25W	441477	4	
R44	RES,CF,2.2K,+-5%,0.25W	343400	1	
R46	RES,CF,12K,+-5%,0.25W	348847	1	
R47	RES,CF,560,+-5%,0.25W	385948	1	
R49,R54,R56	RES,CF,10K,+-5%,0.25W	348839	3	
R50	RES,CF,47,+-5%,0.25W	441592	1	
R57	RES,MF,60.4K,+-1%,0.125W,100PPM	291419	1	
R58	RES,MF,1K,+-1%,0.125W,100PPM	168229	1	
R59,R60	RES,MF,4.99K,+-1%,0.125W,100PPM	721548	2	
R62	RES,CF,4.7K,+-5%,0.25W	348821	1	
R67	RES,MF,562K,+-1%,0.125W,100PPM	757815	1	
TP1-8	JUMPER,WIRE,NONINSUL,0.200CTR	816090	8	
U1,U3	* IC,OP AMP,50MHZ,CURRENT FEEDBACK AMP	836262	2	
U2,U7	* IC,OP AMP,HI-SLEW RATE,8 PIN DIP	386268	2	
U5,U26	* IC,OP AMP,LO-OFFSET VOLTAGE,LO-NOISE	605980	2	
U8,U19	* IC,CMOS,QUAD BILATERAL SWITCH	910708	2	
U9	* IC,OP AMP,DUAL,JFET INPUT,8 PIN	495192	1	
U10	* IC,CMOS,14BIT DAC,12BIT ACC,CUR OUT	773101	1	
U11,U30,U31	* IC,OP AMP,PRECISION,LOW NOISE	782920	3	
U12	* IC,OP AMP,DUAL,PRECISION MATCH	782375	1	
U13	* IC,OP AMP,JFET INPUT,WIDE BAND	808105	1	
U14,U16	RMS CONVERTER TESTED 400 OHM-A GRADE	842591	2	
U15	* IC,OP AMP,QUAD JFET INPUT,14 PIN	659748	1	
U17	* IC,ARRAY,5 TRANS,NPN,3 ISO,2 DEFF CON	248906	1	
U18	* IC,CMOS,8-1 LINE MUX/DEMUX ANALOG SW	836304	1	
U20	* IC,CMOS,PROGRMBL PERIPHERAL INTERFACE	780650	1	
U21,U22	* IC,COMPARATOR,QUAD,14 PIN DIP	387233	2	
U23,U24	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	2	

Table 6-15. A12 Oscillator Control PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
U25	* IC,VOLT REG,FIXED,+5 VOLTS,1.5 AMPS	428847	1	
VR1,VR2	* ZENER,UNCOMP,10.0V,5%,12.5MA,0.4W	246611	2	
VR3	* ZENER,UNCOMP,5.1V,5%,20.0MA,0.4W	159798	1	
VR4	* ZENER,UNCOMP,6.8V,2%,175.0MA,5.0W	325845	1	
VR5,VR6	* ZENER,UNCOMP,6.8V,5%,37.0MA,1.0W	454595	2	
VR7,VR8	* ZENER,UNCOMP,5.1V,5%,20.0MA,0.5W	853700	2	
Z1	* RNET,CERM,SIP,5700 LO V AMP GAIN	760686	1	
Z2,Z4	* RNET,MF,POLY,SIP,8840 LO V DIVIDER	655811	2	
Z3	RNET,MF,HERM,SIP,5700 LO V DIVIDER	760645	1	
Z5	RES,CERM,DIP,14 PIN,7 RES,10K,+-2%	601911	1	
Z6	RES,CERM,SIP,8 PIN,7 RES,1K,+-2%	414557	1	
Z7,Z8	* RNET,CERM,SIP,5700 LO V DIVIDER	785105	2	
Z9	RES,CERM,DIP,16 PIN,8 RES,5.1K,+-5%	544130	1	
Z10	RES,CERM,SIP,8 PIN,4 RES,4.7K,+-2%	573881	1	

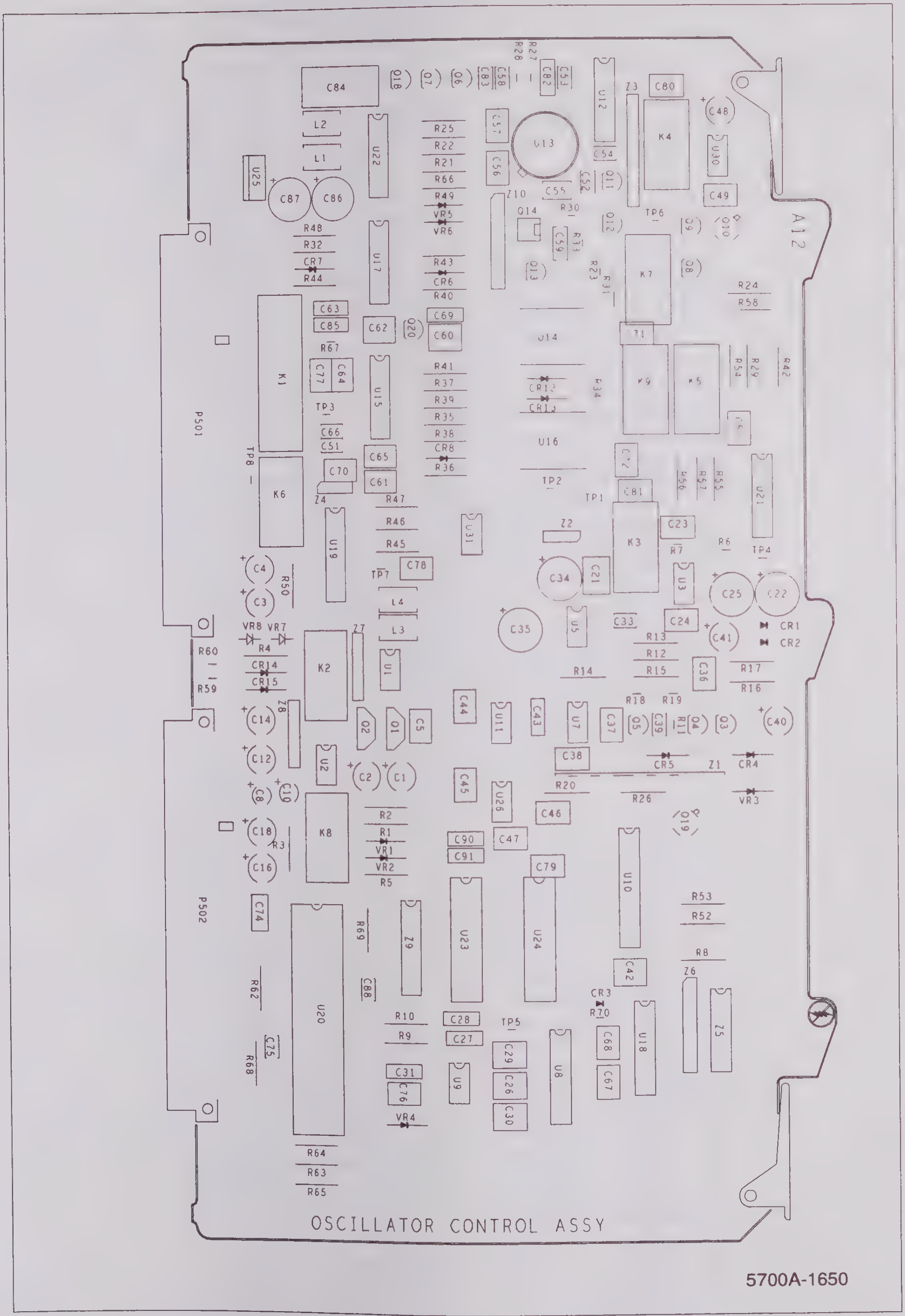

Figure 6-17. A12 Oscillator Control PCA

Table 6-16. A13 Oscillator Output PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C2-4,C16, C20, C23 C26-28,C32, C33,C46,C47, C51,C52,C54, C55,C68-71 C88-92,C102-104, C110,C111, C113,C114	CAP,POLYES,0.22UF,+-5%,50V	747519 747519 747519 747519 747519 747519 747519 747519	33	
C5,C14,C30	CAP,CER,15PF,+-20%,50V,C0G	697524	3	
C6,C15,C31	CAP,CER,82PF,+-2%,50V,C0G	714857	3	
C7,C8	CAP,CER,0.01UF,+-10%,100V,X7R	557587	2	
C17,C29	CAP,CER,2.7PF,+-0.25PF,50V,C0G	773044	2	
C19,C34,C85	CAP,CER,56PF,+-2%,50V,C0G	714378	3	
C21,C37	CAP,MICA,560PF,+-1%,300V	494609	2	
C22,C38	CAP,POLYCA,6150PF,+-1%,50V	800466	2	
C24,C40	CAP,POLYCA,0.0621UF,+-1%,50V	800482	2	
C25,C41	CAP,POLYCA,0.622UF,+-1%,50V	800474	2	
C44,C123	CAP,CER,10PF,+-20%,50V,C0G	721589	2	
C45	CAP,POLYPR,0.033UF,+-10%,63V	721050	1	
C48,C84	CAP,AL,10UF,+-20%,16V,NP,SOLV	697177	2	
C49	CAP,AL,470UF,+-20%,10V,SOLV PROOF	822387	1	
C56-59	CAP,TA,22UF,+-20%,10V	658971	4	
C60,C61,C108, C109	CAP,TA,4.7UF,+-20%,25V	807644 807644	4	
C62	CAP,POLYES,0.47UF,+-10%,50V	697409	1	
C75	CAP,CER,120PF,+-5%,50V,C0G	721142	1	
C76,C77,C124, C125	CAP,CER,1000PF,+-20%,50V,X7R	697458 697458	4	
C78,C79	CAP,POLYES,0.01UF,+-10%,50V	715037	2	
C80,C81	CAP,POLYES,0.1UF,+-10%,50V	649913	2	
C82,C83	CAP,POLYES,1UF,+-10%,50V	733089	2	
C93-99,C106, C107	CAP,TA,10UF,+-20%,25V	714774 714774	9	
C100,C101,C118	CAP,AL,2.2UF,+-20%,50V	769687	3	
C105	CAP,CER,3300PF,+-5%,50V,C0G	830612	1	
C112	CAP,CER,4.7PF,+-0.25PF,50V,C0G	721837	1	
C115	CAP,CER,6800PF,+-5%,100V,C0G	816710	1	
C116,C117	CAP,AL,10UF,+-20%,63V,SOLV PROOF	816843	2	
C119,C120	CAP,CER,33PF,+-5%,50V,C0G	714543	2	
C122	CAP,CER,27PF,+-2%,100V,C0G	816652	1	
C126,C127	CAP,CER,47PF,+-2%,100V,C0G	832295	2	
CR1-11,CR22, CR23	• DIODE,SI,BV=75V,IO=150MA,500MW •	659516 659516	13	
CR13-20	• DIODE,SI,N-JFET,CURRENT REG,IF	852116	8	
H4-7	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
H9-12	SCREW,PH,P,LOCK,STL,6-32,.250	152140	4	
HS1-3	HEAT DIS,RAD,.54X1.25X.35,TO-8	808204	3	
HS4-7	HEAT DIS,CLIP,.80X.85X.30,CASE	800136	4	
HS9,HS10	HEAT DIS,VERT,.83,.50,.395,TO-5	800144	2	
K1	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	1	
K2-4	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307	3	
L1-5,L13,L14	CHOKE,6TURN	320911	7	
L6-12	CORE,TOROID,FERRITE,.047X.138X.118	321182	7	
L15	TRANSFORMER, PULSE	660589	1	
MP2,MP3	EJECTOR,PWB,NYLON	494724	2	
MP4-6	INSUL PT,TRANSISTOR MOUNT,DAP,TO-5	152207	4	
MP8	AIR DUCT, OSCILLATOR	939509	1	

Table 6-16. A13 Oscillator Output PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
MP13-15	SPACER,.375 RND,SOLUBLE,.10THK	837823	3	
P511,P512	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
Q6	* TRANSISTOR,SI,N-JFET,TO-92	832162	1	
Q7	* TRANSISTOR,SI,N-DMOS FET,TO-72	394122	1	
Q8	* TRANSISTOR,SI,NPN,SM SIGNAL,HI	272930	1	
Q9	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698225	1	
Q10,Q11	* TRANSISTOR,SI,100V,10W,TO-202	943803	2	
Q13	* TRANSISTOR,SI,BV=115V,3W,TO-126	601242	1	
Q14	* TRANSISTOR,SI,PNP,70V,400MA,TO-39	866769	1	
Q15	* TRANSISTOR,SI,PNP,40V,0.35W,TO-92	698233	1	
Q16,Q17	* TRANSISTOR,SI,BV=100V,10W,TO-202	943790	2	
R1,R6,R43 R60, R65	RES,MF,2K,+-1%,0.125W,100PPM	816629 816629	5	
R2,R40,R64,R67, R69,R72, R108-110	RES,CF,1K,+-5%,0.25W	780585 780585 780585	9	
R7,R9,R11,R18	RES,CF,200,+-5%,0.25W	810390	4	
R12,R13,R83	RES,MF,4.99K,+-1%,0.125W,100PPM	721548	3	
R19,R37,R50	RES,CF,10K,+-5%,0.25W	697102	5	
R25	RES,CF,39K,+-5%,0.25W	912621	1	
R28	RES,MF,1K,+-1%,0.125W,100PPM	816595	1	
R29,R62,R68	RES,MF,10K,+-1%,0.125W,100PPM	658914	3	
R32	RES,CF,20K,+-5%,0.25W	697110	1	
R33,R38,R51, R78	RES,CF,16K,+-5%,0.25W	714303 714303	4	
R35,R36,R47, R52,R53,R59, R63,R74,R75, R80-82,R107,	RES,CF,4.7K,+-5%,0.25W	721571 721571 721571 721571	13	
R39,R54,R76	RES,CF,12K,+-5%,0.25W	757799	3	
R41	RES,CF,100K,+-5%,0.25W	658963	1	
R42	RES,MF,10.5K,+-1%,0.125W,100PPM	816611	1	
R48	RES,CF,51K+-5%,0.25W	747550	1	
R49	RES,CF,270,+-5%,0.25W	810424	1	
R55,R77	RES,CF,24K,+-5%,0.25W	697599	2	
R56	RES,MF,34.8K,+-0.1%,0.125W,50PPM	772582	1	
R57	RES,CF,43K,+-5%,0.25W	821777	1	
R58	RES,CF,47K,+-5%,0.25W	721787	1	
R61,R66	RES,MF,7.87K,+-1%,0.125W,100PPM	810549	2	
R71,R73	RES,CF,3K,+-5%,0.25W	810366	2	
R84,R85	RES,CF,33K,+-5%,0.25W	733667	2	
R87,R94	RES,CF,100,+-5%,0.25W	810465	2	
R88	RES,CF,4.7,+-5%,0.25W	816637	1	
R89,R90,R9, R98	RES,CF,10,+-5%,0.25W	807669	4	
R91,R99	RES,CF,2.7,+-5%,0.25W	442061	2	
R92,R93,R95, R96	RES,CF,3.9,+-5%,0.25W	810473 810473	4	
R100,R101	RES,MF,30.1K,+-1%,0.125W,100PPM	772061	2	
R111,R112	RES,CF,620,+-5%,0.25W	810408	2	
S1	SWITCH,SLIDE,SPDT	477984	1	
TP1-10	JUMPER,WIRE,NONINSUL,0.200CTR	816090	10	
U2	* IC,VOLT REG,FIXED,-12 VOLTS,1.5 AMPS	381665	1	
U3,U6,U9	* IC,OP AMP,JFET INPUT,WIDE BAND	808105	3	
U5,U7	* RES NET HYBRID, TESTED	793885	2	
U8,U29	* IC,OP AMP,HI-SLEW RATE,8 PIN DIP	386268	2	
U10	* IC,MULTIPLIER/DIV,4 QUAD,10 MH,DIP	904714	1	

Table 6-16. A13 Oscillator Output PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
U11	* RES NET HYBRID, TESTED	793885	1	
U12,U32,U33	* IC,CMOS,OCTL D F/F W/3-STATE,+EDG TRG	585364	3	
U15,U16,U19	* IC,BPLR,FOUR-QUADRANT MULT,16 PIN DIP	343335	3	
U17,U27	* IC,CMOS,DUAL 4-1 LINE MUX/DMUX ANL SW	429886	2	
U18	* IC,OP AMP,JFET INPUT,8 PIN DIP	472779	1	
U20	* IC,COMPARATOR,DUAL,LO-PWR,8 PIN	478354	1	
U21	* IC,FTTL,QUAD 2 INPUT NAND GATE	654640	1	
U22	* IC,FTTL,DUAL JK F/F,-EDG TRIG	781211	1	
U23	* IC,COMPARATOR,DUAL,HI-SPEED,14 DIP	647123	1	
U24	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	1	
U25	* IC,CMOS,8-1 LINE MUX/DEMUX ANALOG SW	836304	1	
U26	* IC,CMOS,PROGRMBL PERIPHERAL INTERFACE	780650	1	
U28	* IC,CMOS,DUAL 8 BIT DAC,CURRENT	722272	1	
U31	* IC,OP AMP,DUAL,JFET INPUT,8 PIN	495192	1	
VR3,VR4	* ZENER,UNCOMP,9.1V,5%,20MA,0.5W	853788	2	
VR7	* ZENER,UNCOMP,8.2V,5%,20MA,0.4W	810309	1	
Z1	RES,CERM,SIP,6 PIN,5 RES,39K,+-2%	831065	1	
Z2	RES,CERM,DIP,14 PIN,7 RES,10K,+-2%	601911	1	
Z3	RES,CERM,SIP,8 PIN,7 RES,1K,+-2%	414557	1	
Z4,Z5	RES,CERM,SIP,8 PIN,4 RES,10K,+-2%	513309	2	
Z6	RES,CERM,SIP,6 PIN,5 RES,3.6K,+-2%	478818	1	

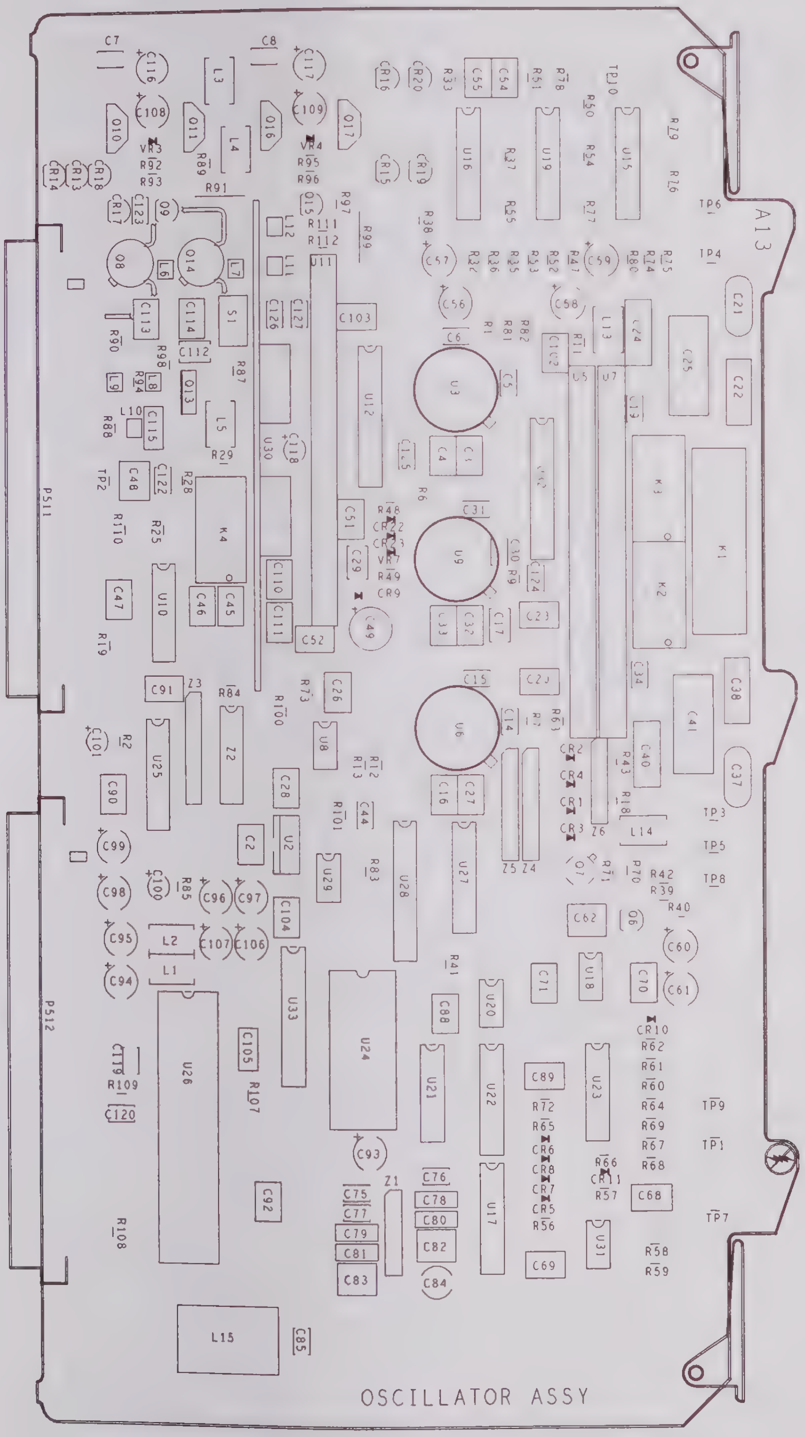

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Figure 6-18. A13 Oscillator Output PCA

Table 6-17. A13A1 Oscillator Wideband SMD PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C3,C4,C6-8, C12,C13	CAP,CER,0.22UF,+80-20%,50V,Y5V	740597 740597	8	
C2	CAP,CER,100PF,+-10%,50V,C0G,1206	740571	1	
C5	CAP,CER,10PF,+-10%,100V,C0G,1206	806943	1	
C9	CAP,CER,470PF,+-10%,50V,C0G,1206	747360	1	
C10	CAP,CER,1000PF,+-10%,50V,C0G,1206	747378	1	
C11	CAP,CER,0.01UF,+-10%,50V,X7R,1206	747261	1	
CR4-6,CR9,C10	* DIODE,SI,BV=70V,IO=50MA,DUAL,SOT-23	742320	5	
P1,P2	HEADER,2 ROW,.100CTR,RT ANG,1206	806935	2	
Q1	* TRANSISTOR,SI,N-JFET,SOT-23	844584	1	
Q2,Q4,Q5	* TRANSISTOR,SI,NPN,SMALL SIGNAL	845438	4	
Q3	* TRANSISTOR,SI,PNP,SMALL SIGNAL	742684	1	
Q6,Q8	* TRANSISTOR,SI,PNP,SMALL SIGNAL	838516	2	
Q9	* TRANSISTOR,SI,NPN,SMALL SIGNAL	742676	1	
R1,R9	* RES,CERM,2K,+-5%,.125W,200PPM	746461	2	
R2	* RES,CERM,2.7K,+-5%,.125W,200PPM	746503	1	
R3,R22	* RES,CERM,330,+-5%,.125W,200PPM	746370	2	
R4,R26	* RES,CERM,510,+-5%,.125W,200PPM	746388	2	
R5	* RES,CERM,5.1K,+-5%,.125W,200PPM	746560	1	
R6,R23,R31	* RES,CERM,3.9K,+-5%,.125W,200PPM	746545	3	
R7,R16,R18,R19, R21 R27-29	* RES,CERM,47,+-5%,.125W,200PPM *	746263 746263	8	
R8	* RES,CERM,100K,+-5%,.125W,200PPM	740548	1	
R10	* RES,CERM,56,+-5%,.125W,200PPM	807727	1	
R11,R17	* RES,CERM,150,+-1%,.125W,100PPM	772780	2	
R12	* RES,CERM,27,+-5%,.125W,200PPM	807735	1	
R13	* RES,CERM,100,+-5%,.125W,200PPM	746297	1	
R14	* RES,CERM,750,+-5%,.125W,200PPM	746404	1	
R15	* RES,CERM,15K,+-5%,.125W,200PPM	746628	1	
R20	* RES,CERM,390,+-5%,.125W,200PPM	740498	1	
R24	* RES,CERM,910,+-5%,.125W,200PPM	769257	1	
R25	* RES,CERM,1.8K,+-5%,.125W,200PPM	746453	1	1
R30	RES,VAR,CERM,1K,+-10%,0.5W	912360	1	
U1	* IC,OP AMP,ULTRA-LOW-NOISE,SOIC	783001	1	
U2	* IC,OP AMP,SINGLE,LOW NOISE FAST,SOIC	783720	1	
VR1,VR5-7	* ZENER,UNCOMP,6.2V,5%,20MA,0.2W	782441	4	
VR2	* ZENER,UNCOMP,22V,5%,5.6MA,0.2W	831230	1	
VR3,VR4	* ZENER,UNCOMP,3.3V,5%,20MA,0.2W	807008	2	

1. R25 is selected at test as one of the following: 1.8k (746453), 2K (746461), or 2.2K.

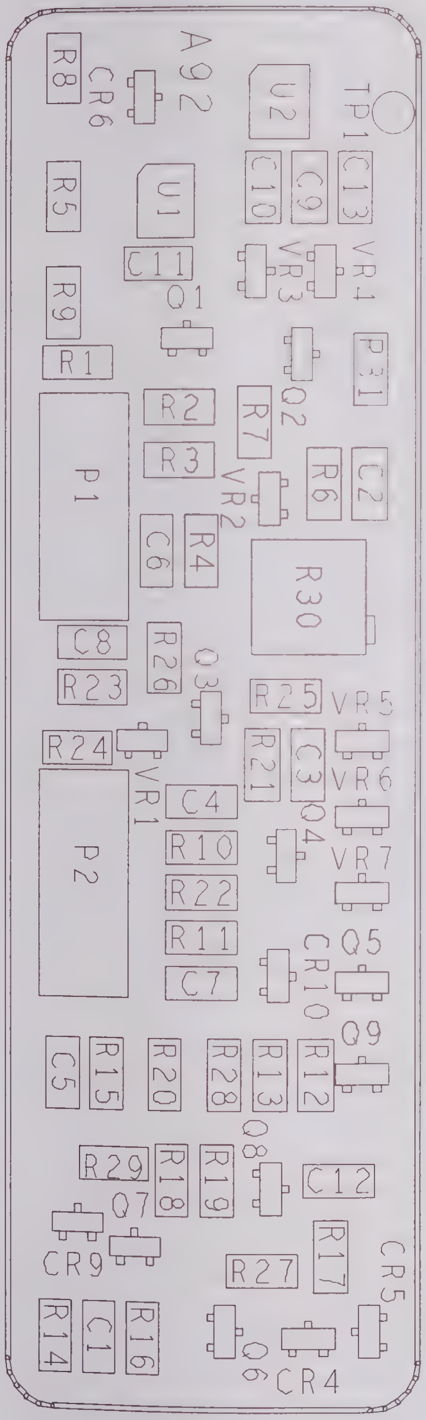

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Figure 6-19. A13A1 Oscillator Wideband SMD PCA

Table 6-18. A14 High Voltage Control PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1	CAP,POLYES,0.72UF,+-20%,1300V	853929	1	
C2	CAP,POLYES,0.1UF,+-20%,1400V	821512	1	
C3,C4	CAP,AL,470UF,+-20%,16V,SOLV PROOF	772855	2	
C5	CAP,POLYES,1UF,+-10%,50V	733089	1	
C6,C7	CAP,TA,10UF,+-20%,35V	816512	2	
C8,C9	CAP,AL,10UF,+-20%,63V,SOLV PROOF	816843	2	
C10,C20,C24-32	CAP,POLYES,0.1UF,+-10%,50V	649913	11	
C11-13	CAP,TA,22UF,+-20%,10V	658971	3	
C14	CAP,CER,330PF,+-5%,50V,C0G	697441	1	
C15	CAP,CER,120PF,+-5%,50V,C0G	721142	1	
C17	CAP,POLYES,2200PF,+-10%,50V	832683	1	
C18	CAP,TA,1UF,+-20%,35V	697417	1	
C21,C22	CAP,CER,33PF,+-5%,50V,C0G	714543	2	
C23	CAP,CER,1000PF,+-20%,50V,X7R	697458	1	
C33	CAP,CER,27PF,+-2%,100V,C0G	816652	1	
CR1-4	* DIODE,SI,HIGH VOLTAGE,PIV=2K,40MA	851956	4	
CR5	DIODE,SI,RECT,BRIDGE,BV=50V,IO=3A	586115	1	
CR6-12	* DIODE,SI,BV=75V,IO=150MA,500MW	659516	7	
H4-7	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
H8,H9,H11	SCREW,PH,P,LOCK,STL,6-32,.250	152140	3	
J1	CONN,MATE-N-LOK,HEADER,14 PIN	845318	1	
K1,K2,K4 K8, K10,K11,K14	RELAY,ARMATURE,2 FORM C,5V	733063 733063	7	
K3,K5,K6 K9, K12,K013 K15, K16	RELAY,ARMATURE,1 FORM A/1 FORM	831545 831545 831545	8	
K7	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307	1	
L1	CHOKE,6TURN	320911	1	
MP1,MP2	EJECTOR,PWB,NYLON	494724	2	
MP3	SHIELD, HIGH VOLTAGE CONTROL	786616	1	
MP5	CABLE ACCESS,TIE,5.50L,.10W,1.25 DIA	530360	1	
MP8	HEAT DIS,PRESS ON,TO-5	418384	1	
MP10,MP13	WASHER,FLAT,STL,.149,.375,.031	110270	2	
P611,P612	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
Q2	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698225	1	
Q3,Q4	* TRANSISTOR,SI,P-JFET,TO-92	852111	2	
R1,R2	RES,CC,47,+-5%,0.5W	159608	2	
R3-5	RES,CC,200K,+-5%,1W	109926	3	
R6,R8	RES,MF,23.2,+-1%,0.5W,100PPM	200790	2	
R7	RES,CF,22K,+-5%,0.25W	747535	1	
R9,R12,R64	RES,CF,1.5M,+-5%,0.25W	649962	3	
R10,R11	RES,CF,1.5M,+-5%,0.25W	649962	2	
R13	RES,CF,9.1K,+-5%,0.25W	706663	1	
R14,R15	RES,CF,620,+-5%,0.25W	810408	2	
R17,R46,R55	RES,CF,100K,+-5%,0.25W	658963	3	
R18	RES,CF,1K,+-5%,0.25W	780585	1	
R19	RES,MF,162K,+-1%,0.125W,100PPM	817569	1	
R20	RES,MF,412K,+-1%,0.125W,50PPM	714287	1	
R21,R24,R33, R34,R47,R56, R68,R69	RES,CF,10K,+-5%,0.25W	697102 697102 697102	8	
R22	RES,CC,3K,+-5%,0.5W	109090	1	
R23	RES,CF,200K,+-5%,0.25W	681841	1	
R25	RES,CF,750K,+-5%,0.25W	747543	1	
R26,R44,R45	RES,MF,100K,+-1%,0.125W,100PPM	757807	3	
R27,R29	RES,MF,36.5K,+-1%,0.125W,100PPM	820324	2	

Table 6-18. A14 High Voltage Control PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
R28	RES,MF,20.5K,+-1%,0.125W,100PPM	655233	1	
R30-32	RES,MF,18.2K,+-1%,0.125W,100PPM	756429	3	
R35-39,R50,R52	RES,MF,196K,+-1%,0.125W,100PPM	769984	7	
R40,R41	RES,MF,464K,+-1%,0.125W,100PPM	772020	2	
R42	RES,CF,1.5K,+-5%,0.25W	810432	1	
R43	RES,MF,301K,+-1%,0.125W,100PPM	655274	1	
R54	RES,CF,2K,+-5%,0.25W	810457	1	
R57,R58	RES,CF,750,+-5%,0.25W	810374	2	
R59	RES,CF,16K,+-5%,0.25W	714303	1	
R60,R61	RES,CF,20K,+-5%,0.25W	697110	2	
R62,R63	RES,CF,3K,+-5%,0.25W	810366	2	
R65,R66	RES,CF,10,+-5%,0.25W	807669	2	
R67	RES,CF,3.9,+-5%,0.25W	810473	1	
R70,R71	RES,CC,4.7M,+-5%,0.25W	220046	2	
T1	TRANSFORMER, HIGH VOLTAGE	775288	1	
TP1-6	JUMPER,WIRE,NONINSUL,0.200CTR	816090	6	
U1	* IC,OP AMP,DUAL,LO OFFST,VOLT,LO-DRIFT	685164	1	
U2	* IC,OP AMP,QUAD,JFET INPUT,14 PIN	483438	1	
U3	* IC,OP AMP,SINGLE,HIGH VOLTAGE	782342	1	
U4	* IC,CMOS,MONOSTABL/ASTABL MULTIVIBRATR	535575	1	
U6,U7	* IC,CMOS,QUAD BILATERAL SWITCH	910708	2	
U8	* IC,CMOS,HEX INVERTER,UNBUFFERED	741199	1	
U9	* IC,CMOS,PROGRMBL PERIPHERAL INTERFACE	780650	1	
U10-13	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	4	
U14	* IC,CMOS,8-1 LINE MUX/DEMUX ANALOG SW	836304	1	
VR1	* ZENER,UNCOMP,6.8V,5%,20.0MA,0.4W	820431	1	
VR2,VR3	* ZENER,TRANS SUPPRESSOR,400V,5%	845003	2	
VR4,VR5	* ZENER,UNCOMP,16.0V,5%,15.5MA,1.0W	313221	2	
VR6,VR7	* ZENER,UNCOMP,3.3V,5%,20.0MA,0.4W	820423	2	
VR8	* ZENER,UNCOMP,18.0V,5%,7.0MA,0,4W	327973	1	
Z1	RES,CERM,SIP,8 PIN,7 RES,10K,+-2%	412924	1	

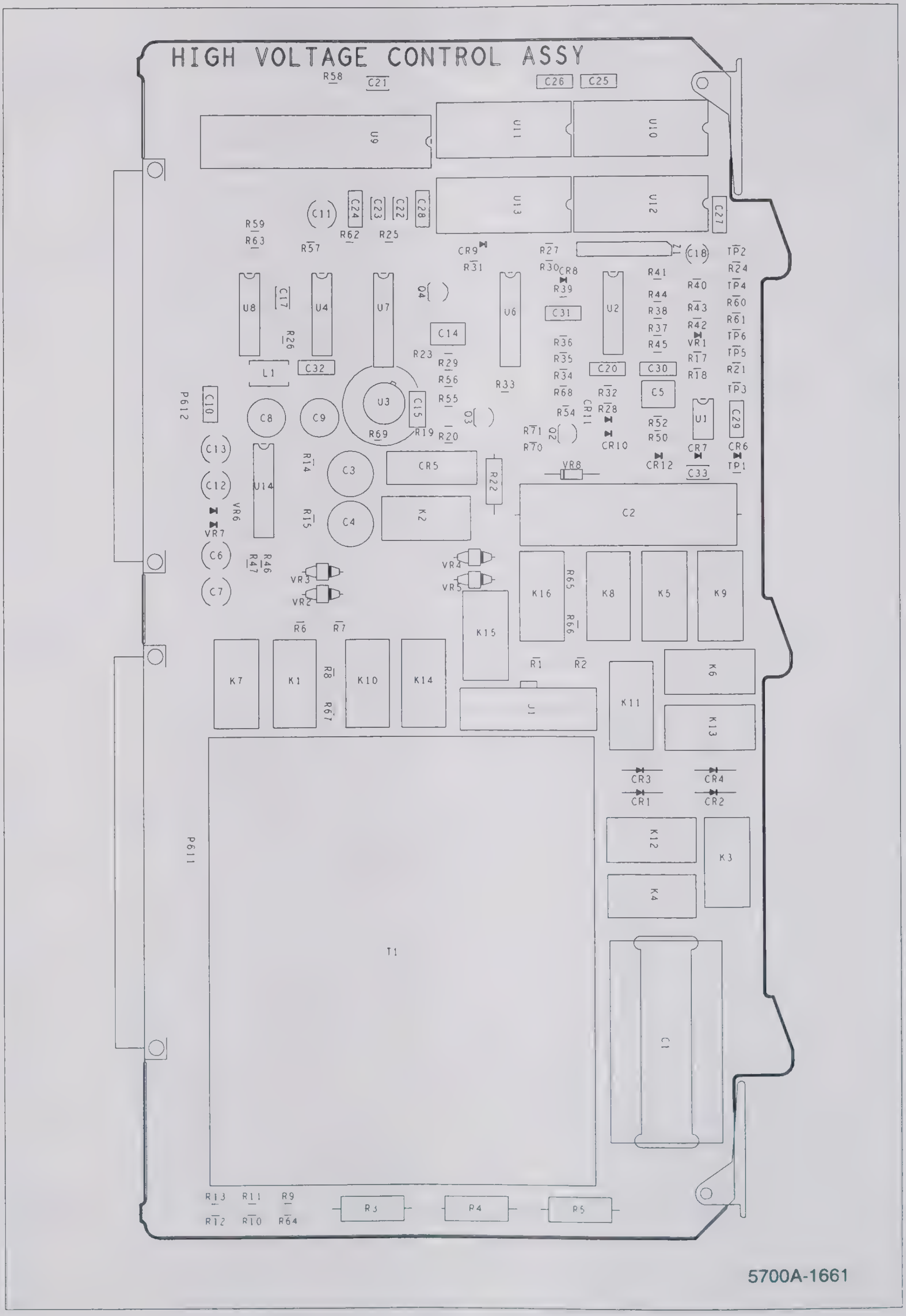

Figure 6-20. A14 High Voltage Control PCA

Table 6-19. A15 High Voltage/High Current PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C2,C29,C42	CAP,POLYES,0.01UF,+-10%,50V	715037	3	
C4	CAP,POLYPR,0.022UF,+-5%,1500V	806968	1	
C5,C15-17,C20, C21 C23-28,C32 C33,C35,C38,C40	CAP,POLYES,0.1UF,+-10%,50V	649913 649913 649913	17	
C6	CAP,POLYES,0.047UF,+-10%,50V	820548	1	
C7	CAP,CER,180PF,+-2%,50V,C0G	820522	1	
C8	CAP,CER,680PF,+-5%,50V,C0G	743351	1	
C10	CAP,CER,82PF,+-2%,50V,C0G	714857	1	
C11	CAP,CER,47PF,+-20%,50V,C0G	706705	1	
C12,C13,C43	CAP,POLYES,0.47UF,+-10%,50V	697409	3	
C14,C19	CAP,TA,2.2UF,+-10%,35V	697433	2	
C18	CAP,CER,100PF,+-5%,50V,C0G	831495	1	
C22	CAP,POLYES,0.01UF,+-10%,50V	715037	1	
C30,C31,C37,C39	CAP,TA,10UF,+-20%,35V	816512	4	
C34	CAP,TA,22UF,+-20%,10V	658971	1	
C41	CAP,POLYES,0.22UF,+-10%,50V	706028	1	
CR1,CR4 CR11- 16,CR24,CR25	* DIODE,SI,BV=75V,IO=150MA,500MW *	203323 203323	10	
CR2,CR17,CR18, CR20,CR21	* DIODE,SI,N-JFET,CURRENT REG,IF *	852116 852116	5	
CR5,CR6,CR9, CR10 CR22, CR23	DIODE,SI,100 PIV,1 AMP	742874 742874 742874	6	
CR19	* DIODE,SI,N-JFET,CURRENT REG,IF	852124	1	
H1,H2	SCREW,PH,P,LOCK,SS,6-32,.500	320051	2	
H4	* HYBRID ASSEMBLY, TESTED	813444	1	
H6-10,H21	SCREW,PH,P,LOCK,STL,6-32,.250	152140	6	
H17-20	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
HR7	* HIGH VOLTAGE DC HYBRID	775254	1	
K1	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	1	
K2,K3	RELAY,ARMATURE,2 FORM C,5V,LATCH	769307	2	
K4,K5,K8,K9,K12	RELAY,ARMATURE,2 FORM C,5V	733063	5	
K6,K7,K10,K11, K14	RELAY,ARMATURE,1 FORM A/1 FORM	831545 831545	5	
L4,L5	CHOKE,6TURN	320911	2	
MP1,MP2	EJECTOR,PWB,NYLON	494724	2	
MP3	SHIELD, HIGH VOLTAGE, REAR	786525	1	
MP4	MOLDED COVER, REF. HYBRID	797746	1	
MP5	MOLDED COVER, HYBRID, R-NET	775619	1	
MP6-9	SPACER,BROACH,SNAP,BR,1.062	832469	4	
MP10	THERMAL INSULATOR, HIGH VOLTAG	797829	1	
MP11,MP12	INSUL PT,TRANSISTOR MOUNT,DAP,T0-5	152207	2	
MP14-16	CABLE TIE,5",1.375"DIA	807230	3	
MP22	HI VOLT CLAMP BAR	760850	1	
P601,P602	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
Q3,Q13	* TRANSISTOR,SI,NPN,SMALL SIGNAL	346916	2	
Q4,Q15,Q22,Q23	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698225	4	
Q6,Q12	* TRANSISTOR,SI,PNP,SMALL SIGNAL	402586	2	
Q8,Q18	* TRANSISTOR,SI,BV=40V,40W,TO-220	369660	2	
Q9,Q19	* TRANSISTOR,SI,BV=60V,65W,TO-220	386128	2	
Q10	* TRANSISTOR,SI,P-JFET,TO-92	852111	1	
Q11	* TRANSISTOR,SI,BV=100V,50W,TO-220	454041	1	
Q14	* TRANSISTOR,SI,BV=100V,40W,TO-220	454033	1	
Q16,Q24	* TRANSISTOR,SI,PNP,40V,0.35W,TO-92	698233	2	
Q20,Q21	* TRANSISTOR,SI,N-JFET,SEL,TO-92	707703	2	

Table 6-19. A15 High Voltage/High Current PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
R1,R72	RES,CF,1K,+-5%,0.25W	343426	2	
R2,R15,R39	RES,CF,100K,+-5%,0.25W	348920	3	
R4,R11,R51 R53, R61-64,R74	RES,CF,100,+-5%,0.25W	348771 348771	9	
R5	RES,CF,1.5K,+-5%,0.25W	810432	1	
R6,R9	RES,CF,1M,+-5%,0.25W	348987	2	
R7	RES,CF,51K+-5%,0.25W	747550	1	
R8,R19	RES,CF,3K,+-5%,0.25W	441527	2	
R10	RES,CF,820,+-5%,0.25W	442327	1	
R12	RES,CF,33K,+-5%,0.25W	733667	1	
R13	RES,MF,34.8K,+-1%,0.125W,100PPM	772319	1	
R14,R16,R21, R27,R28,R40, R44,R52,R54, R71	RES,CF,10K,+-5%,0.25W	348839 348839 348839 348839	10	
R17,R41	RES,CF,4.7K,+-5%,0.25W	348821	2	
R18	RES,CF,22K,+-5%,0.25W	348870	1	
R20	RES,CF,1.5K,+-5%,0.25W	343418	1	
R22	RES,CF,16K,+-5%,0.25W	442376	1	
R23,R24,R60, R65	RES,CF,10,+-5%,O.25W	340075 340075	4	
R25,R26	RES,MF,14.3,+-1%,0.125W,100PPM	447144	2	
R29,R30	RES,CF,8.2K,+-5%,0.25W	441675	2	
R31,R32	RES,CC,2K,+-5%,0.5W	169854	2	
R33-35	RES,CC,470,+-10%,0.5W	108415	3	
R36	RES,CF,47,+-5%,0.25W	441592	1	
R37,R38	RES,MF,825,+-1%,0.125W,100PPM	294892	2	
R42,R43,R45, R46	RES,MF,10K,+-1%,0.125W,100PPM	168260 168260	4	
R47	RES,CF,160,+-5%,0.25W	441410	1	
R48,R50	RES,MF,2.21K,+-1%,0.125W,100PPM	347476	2	
R56,R69	RES,MF,191,+-1%,0.125W,100PPM	325639	2	
R57,R68,R77, R78	RES,WW,.1,+-3%,.7W	255679 255679	4	
R58,R67	RES,CF,330K,+-5%,0.25W	376640	2	
R59,R66	RES,CF,68,+-5%,0.25W	414532	2	
R73,R75	RES,CF,2K,+-5%,0.25W	441469	2	
R76	RES,CF,3.3,+-5%,0.25W	348730	1	
R79,R82	RES,CF,1K,+-5%,0.25W	780585	2	
R80,R83	RES,CF,4.7K,+-5%,0.25W	721571	2	
R81,R84	RES,CF,10K,+-5%,0.25W	697102	2	
TP1,TP3-11	JUMPER,WIRE,NONINSUL,0.200CTR	816090	10	
TP2	SOCKET,SINGLE,PWB,FOR 0.080 PIN	170480	1	
U1	* IC,OP AMP,JFET INPUT,22V SUPPLY,DIP	832584	1	
U2,U4,U5	* IC,OP AMP,JFET INPUT,8 PIN DIP	472779	3	
U3	* IC,OP AMP,DUAL,LO OFFST,VOLT,LO-DRIFT	685164	1	
VR1,VR2,VR5, VR6	* ZENER,UNCOMP,16.0V,5%,15.5MA,1.0W *	313221 313221	4	
VR3,VR4	* ZENER,UNCOMP,20.0V,5%,6.2MA,0.4W	180463	2	
VR7,VR8	* ZENER,UNCOMP,16.0V,5%,7.8MA,0.4W	325837	2	
W1	CABLE ASSEMBLY, HIGH VOLTAGE 8.125”	881862	1	
W2,W3	CABLE ASSEMBLY, HIGH VOLTAGE 7.375”	881859	2	
Z5	* R-NET/HEAT SINK ASSY-4R03	761288	1	
Z6	* R-NET/HEAT SINK ASSY-4R23	761296	1	

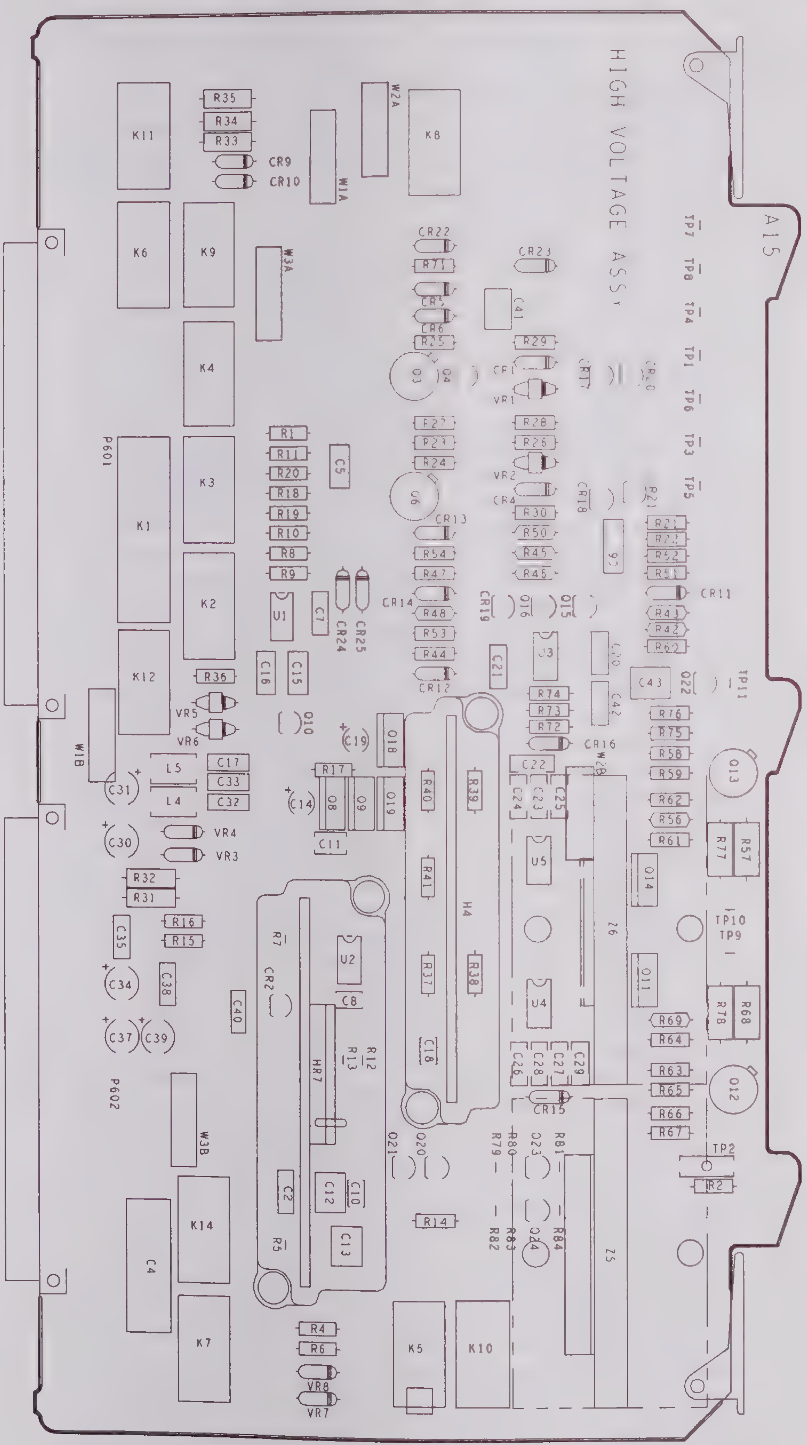

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Figure 6-21. A15 High Voltage/High Current PCA

Table 6-20. A16 Power Amplifier PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C2,C63	CAP,CER,10PF,+-10%,3000V,C0G	817049	3	
C3	CAP,MICA,560PF,+-5%,500V	170431	1	
C4,C28	CAP,CER,0.02UF,+-20%,500V,Z5U	407403	2	
C5,C75	CAP,POLYES,0.047UF,+-10%,50V	820548	2	
C6,C17,C23	CAP,CER,22PF,+-10%,1000V,C0G	817023	3	
C7,C24,C43	CAP,CER,1000PF,+-20%,50V,X7R	697458	3	
C8,C13,C16,C20, C47,C49,C60,C61, C68-71	CAP,POLYES,0.22UF,+-5%,50V	747519 747519 747519	12	
C9,C21	CAP,TA,15UF,+-20%,20V	807610	2	
C10,C25	CAP,TA,1UF,+-20%,35V	697417	2	
C11	CAP,CER,22PF,+-2%,50V,C0G	714832	1	
C12	CAP,CER,2000PF,+-20%,100V,Z5U	757096	1	
C15	CAP,CER,0.01UF,+80-20%,500V,Z5	816991	1	
C18	CAP,CER,6.8PF,+-0.1PF,500V,C0J	485383	1	
C19	CAP,CER,100PF,+-5%,50V,C0G	831495	1	
C22	CAP,MICA,2PF,+-0.5PF,500V	175208	1	
C26	CAP,CER,1000PF,+-20%,3000V,Z5U	832709	1	
C27,C78,C79	CAP,AL,3.3UF,+30-20%,450V	782524	3	
C31-34	CAP,AL,22UF,+-20%,35V	817056	4	
C40	CAP,POLYES,1UF,+-10%,50V	733089	1	
C41	CAP,POLYPR,0.15UF,+-10%,400V	557504	1	
C42	CAP,CER,470PF,+-10%,50V,C0G	733071	1	
C45	CAP,TA,2.2UF,+-10%,35V	697433	1	
C48,C72	CAP,CER,1.2PF,+-0.25PF,50V,C0K	715235	2	
C57	CAP,CER,100PF,+-10%,1000V,S3N	816983	1	
C65,C67	CAP,TA,4.7UF,+-20%,25V	807644	2	
C73	CAP,CER,0.05UF,+80-20%,500V,Z5	105676	1	
C74	CAP,POLYES,0.1UF,+-10%,50V	649913	1	
C80,C81	CAP,POLYES,0.47UF,+-10%,50V	697409	2	
C82	CAP,CER,10PF,+-2%,50V,C0G	713875	1	
CR1-5,CR7,CR10, CR12-014,CR16, CR20,CR21,CR23- 025,CR27,CR29- 31,CR61-67	* DIODE,SI,BV=75V,IO=150MA,500MW * * * *	659516 659516 659516 659516 659516	27	
CR8,CR9	DIODE,SI,100 PIV,1 AMP	820449	2	
CR18,CR19	* DIODE,SI,BV=125V,IO=150MA,500 MW	844647	2	
CR33,CR68, CR69	* DIODE,SI,N-JFET,CURRENT REG,IF *	852116 852116	3	
CR35-39	DIODE,SI,BV=200V,IO=200MA	876867	5	
CR53	* DIODE,SI,N-JFET,CURRENT REG,IF	334839	1	
H1,H2	SCREW,PH,P,LOCK,SS,6-32,.500	320051	2	
H3,H4	SCREW,PH,P,LOCK,SS,6-32,.750	376822	2	
H10,H48,H59,H60	SCREW,PH,P,LOCK,SS,6-32,.375	334458	4	
H13-16	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
HR8	* POWER AMP DC HYBRID	775437	1	
K1,K2	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	2	
K3,K4	RELAY,ARMATURE,2 FORM C,5V,LATCCH	769307	2	
K10,K11,K13-16	RELAY,ARMATURE,2 FORM C,5V	733063	6	
K12,K17	RELAY,ARMATURE,2 FORM C,5VDC,HI IR	911271	2	
L1-3	CHOKE,6TURN	320911	3	
L10	INDUCTOR,1.5UH,+-5%,128MHZ,SHLD	413856	1	
L12	CHOKE,2TURN	417196	1	
M17	OSCILLATOR THERMAL COVER	797696	1	
MP4	MOLDED COVER, HYBRID, R-NET	775619	1	

Table 6-20. A16 Power Amplifier PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
MP5-8	HEAT DIS,PRESS ON,TO-5	418384	4	
MP20-23	INSUL PT,TRANSISTOR MOUNT,DAP,TO-5	152207	4	
MP41,MP42, MP45-47	SCREW,PH,P,LOCK,STL,6-32,.250	152140 152140	5	
MP43,MP44	EJECTOR,PWB,NYLON	494724	2	
MP49	HEATSINK, POWER AMP	803007	1	
MP50	SHIELD, HIGH VOLTAGE, REAR	786525	1	
MP51-54	INSUL PT,TRANSISTOR,NYL,.4,.61	844837	4	
MP55	THERMAL INSULATOR, POWER AMP	791988	1	
MP56,MP57	POWER AMP CLAMP BAR	803015	2	
MP58	RIVETED AIR DUCT ASSEMBLY	883830	1	
P701,P702	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
Q1,Q3	TRANSISTOR,SI,N-MOS,40W,500V,T0-220	782540	2	
Q2	* TRANSITOR,SI,N-JFET,UHF/VHF US	851972	1	
Q4,Q7,Q32 Q60, Q62	* TRANSISTOR,SI,NPN,SMALL SIGNAL *	698225 698225	5	
Q5	* TRANSISTOR,SI,NPN,HI-FREQ,T0-39	912522	1	
Q6	* TRANSISTOR,SI,PNP,SMALL SIGNAL	844993	1	
Q8	* TRANSISTOR,SI,N-DMOS FET,TO-72	394122	1	
Q9,Q16,Q54	* TRANSISTOR,SI,NPN SMALL SIGNAL	853478	3	
Q10	* TRANSISTOR,SI,PNP,70V,400MA,TO-39	866769	1	
Q11	* TRANSISTOR,SI,PNP,SWITCHING,TO-92	831446	1	
Q12,Q14	* TRANSISTOR,SI,N-DMOS,500V,TO-39	783753	2	
Q13	* TRANSISTOR,SI,P-MOS,500V,TO-92	782508	1	
Q15,Q17	* TRANSISTOR,SI,P-MOS,POWER,500V	782482	2	
Q31	* TRANSISTOR,SI,VMOS,PWR,TO-237,VN10KM	640516	1	
Q33,Q34	* TRANSISTOR,SI,N-JFET,SEL,TO-92	707703	2	
Q35	* TRANSISTOR,SI,BV=60V,65W,TO-220	386128	1	
Q38	* TRANSISTOR,SI,BV=40V,40W,TO-220	369660	1	
Q39,Q40,Q50, Q51,Q57,Q58	* TRANSISTOR,SI,N-DMOS PWR FET,T0-92 *	782565 782565	6	
Q61	* TRANSISTOR,SI,PNP,40V,0.35W,TO-92	698233	1	
R1	RES,CF,9.1K,+-5%,0.25W	706663	1	
R2,R18,R54,R56, R89,R90,R134, R135	RES,CF,10K,+-5%,0.25W	697102 697102 697102	8	
R3,R4,R81-83	RES,MF,100K,+-0.1%,0.5W,50PPM	369371	5	
R5	RES,MF,30.1K,+-1%,0.125W,100PPM	772061	1	
R6	RES,CF,51K+-5%,0.25W	747550	1	
R7	RES,MF,1.5M,+-1%,0.125W,100PPM	714998	1	
R8,R86	RES,MF,10K,+-0.1%,0.125W,50PPM	733972	2	
R9,R10,R16,R33, R40,R50 R59, R115,R148 R149	RES,MF,1K,+-1%,0.125W,100PPM	816595 816595 816595	10	
R11,R12	RES,MF,16.5K,+-1%,0.5W,100PPM	162529	2	
R13	RES,MF,17.4K,+-1%,0.5W,100PPM	247270	1	
R14,R73,R137	RES,CF,43K,+-5%,0.25W	821777	3	
R15,R19,R52, R57	RES,CC,68K,+-10%,1W	109629 109629	4	
R17,R53	RES,MF,4.99K,+-1%,0.125W,100PPM	721548	2	
R20,R23	RES,CF,3.9K.+-5%,0.25W	810416	2	
R22,R109,R133	RES,CF,430,+-5%,0.25W	817577	3	
R24,R138	RES,CF,200,+-5%,0.25W	810390	2	
R25,R32	RES,CF,750,+-5%,0.25W	810374	2	
R26,R126,R128	RES,CF,620,+-5%,0.25W	810408	3	
R27	RES,CC,1K,+-5%,0.5W	108597	1	

Table 6-20. A16 Power Amplifier PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
R28,R29,R34, R47	RES,MF,499K,+-1%,0.125W,100PPM	714980 714980	4	
R30	RES,CF,330,+-5%,0.25W	830596	1	
R31	RES,CF,100K,+-5%,0.25W	658963	1	
R35,R74,R139	RES,CF,20,+-5%,0.25W	810382	3	
R36,R141,R151, R152	RES,CF,47,+-5%,0.25W	822189 822189	4	
R37	RES,CF,12K,+-5%,0.25W	757799	1	
R38,R118	RES,CF,47K,+-5%,0.25W	721787	2	
R41,R51,R55	RES,CC,200K,+-5%,1W	109926	3	
R46,R108 R110- 113	RES,CF,100,+-5%,0.25W	810465 810465	6	
R58	RES,CF,33,+-5%,0.25W	414524	1	
R61	RES,CF,750K,+-5%,0.25W	747543	1	
R84	RES,MF,22.1K,+-1%,0.125W,100PPM	655266	1	
R85	RES,CC,27M,+-5%,0.25W	221994	1	
R87	RES,MF,84.5,+-1%,0.125W,100PPM	236851	1	
R88,R97,R98	RES,MF,10,+-1%,0.125W,100PPM	820399	3	
R92	RES JUMPER,0.02,0.25W	682575	1	
R116,R129	RES,CF,4.7K,+-5%,0.25W	721571	2	
R117	RES,CF,24K,+-5%,0.25W	697599	1	
R120	RES,CC,47,+-5%,0.5W	159608	1	
R125	RES,CF,2K,+-5%,0.25W	810457	1	
R132	RES,MF,20K,+-0.1%,0.25W,25PPM	810564	1	
R142	RES,CF,200K,+-5%,0.25W	681841	1	
R143	RES,CF,300K,+-5%,0.25W	732818	1	
R144	RES,CF,1K,+-5%,0.25W	780585	1	
R146,R147	RES,CF,2.4,+-5%,0.25W	348508	2	
R150	RES,CF,15,+-5%,0.25W	348755	1	
TP1-5,TP7-13, TP16,TP17	JUMPER,WIRE,NONINSUL,0.200CTR	816090 816090	14	
TP6	SOCKET,SINGLE,PWB,FOR 0.080 PIN	170480	1	
TP14	SOCKET,SINGLE,PWB,FOR 0.080 PIN	149138	1	
TP15	SOCKET,SINGLE,PWB,FOR 0.080 PIN	149120	1	
U1	* IC,OP AMP,PRGRBL OUT CURRNT,8 PIN	418913	1	
U2,U5	* IC,CMOS,QUAD BILATERAL SWITCH	910708	2	
U4	* IC,OP AMP,HIGH SPEED,LOW NOISE	875815	1	
U7	* IC,OP AMP,JFET INPUT,22V SUPPLY,DIP	832584	1	
U8	* IC,CMOS,HEX INVERTER	381848	1	
U9	* IC,OP AMP,CHOPPER STABLIZED,8 PIN	831263	1	
U10	* IC,BPLR,FAHRENHEIT TEMPERTURE	845156	1	
VR6,VR11,VR19, VR22 VR26,VR28 VR32	* ZENER,UNCOMP,10.0V,5%,12.5MA,0.4W * *	810267 810267 810267	7	
VR15	* ZENER,UNCOMP,18.0V,5%,7.0MA,0.4W	810325	1	
VR18	* ZENER,UNCOMP,15.0V,5%,8.5MA,0.4W	820415	1	
VR51,VR52,VR57, VR58	* ZENER,UNCOMP,6.8V,5%,20.0MA,0.4W *	820431 820431	4	
VR61,VR62	* ZENER,UNCOMP,3.3V,5%,20.0MA,0.4W	820423	2	
VR64	* ZENER,UNCOMP,24.0V,5%,20MA,0,4W	810317	1	
VR65	* ZENER,UNCOMP,8.2V,5%,20MA,0.4W	810309	1	
Z1	* RNET,MF,HERM,SIP,5700 HI V DIVIDER	764399	1	

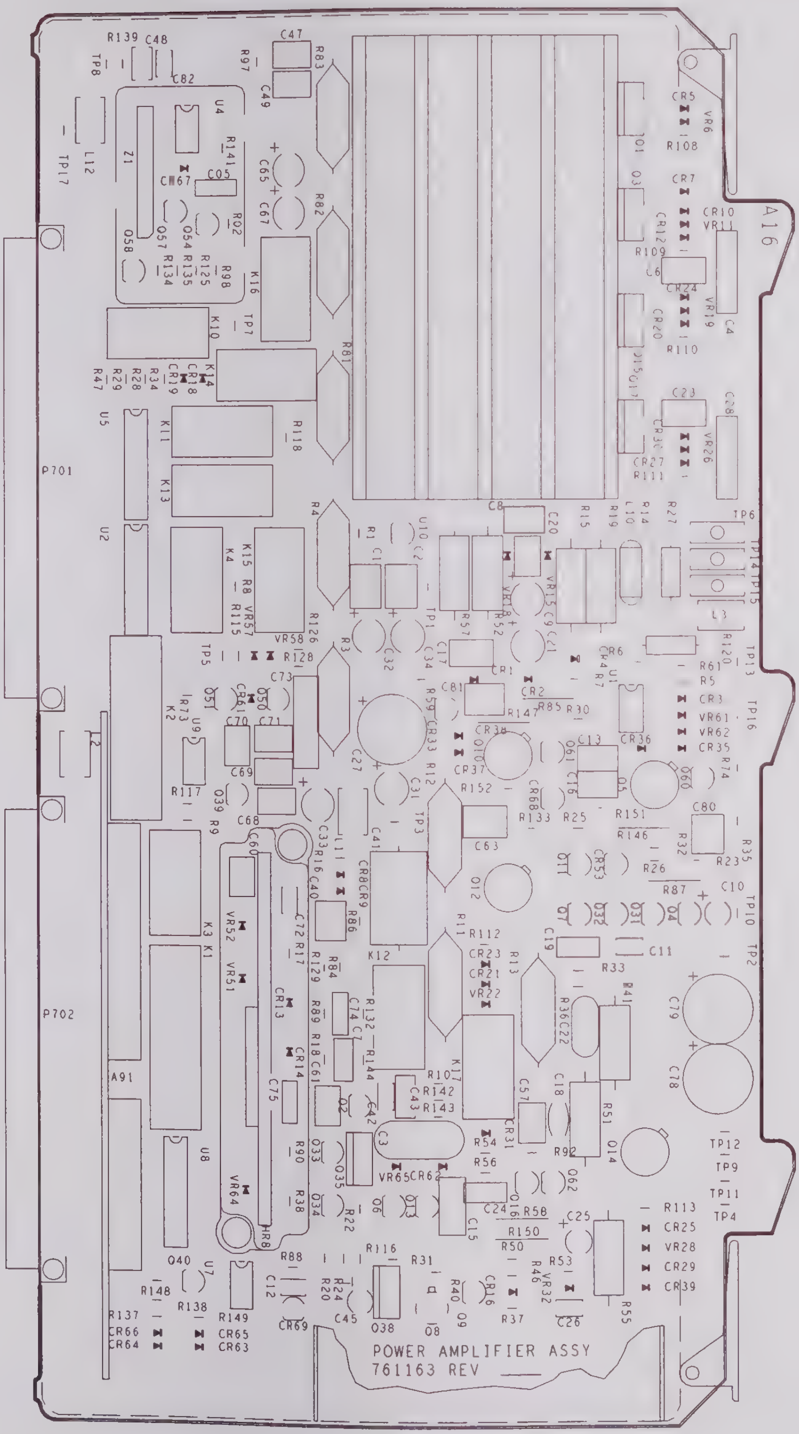

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Figure 6-22. A16 Power Amplifier PCA

Table 6-21. A16A1 Power Amplifier Digital Control SIP PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C52	CAP,AL,15UF,+-20%,35V	614024	1	
C53,C56	CAP,CER,33PF,+-5%,50V,C0G	714543	2	
C54	CAP,CER,470PF,+-10%,50V,C0G	733071	1	
C55,C57	CAP,POLYES,0.22UF,+-5%,50V	747519	2	
L4	CHOKE,6TURN	320911	1	
MP3	HEADER,2 ROW,.100CTR,RT ANG,10 PIN	658112	1	
P1,P2	HEADER,2 ROW,.100CTR,RT ANG,26 PIN	512590	2	
R2,R106	RES,CF,1K,+-5%,0.25W	780585	2	
R101,R105	RES,MF,1K,+-1%,0.125W,100PPM	816595	2	
R102	RES,CF,16K,+-5%,0.25W	714303	1	
R103	RES,CF,10K,+-5%,0.25W	697102	1	
R104	RES,CF,4.7K,+-5%,0.25W	721571	1	
U9	* IC,LSTTL,3-8 LINE DCDR W/ENABL	407585	1	
U10,U12	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	2	
U11	* IC,CMOS,PROGRMBL PERIPHERAL INTERFACE	780650	1	
U13,U15	* IC,COMPARATOR,QUAD,14 PIN DIP	387233	2	
U14	* IC,CMOS,8-1 LINE MUX/DEMUX ANALOG,SW	836304	1	
Z1	RES,CERM,SIP,10 PIN,9 RES,47K,+-2%	485193	1	
Z2	RES,CERM,SIP,10 PIN,9 RES,4.7K,+-2%	484063	1	

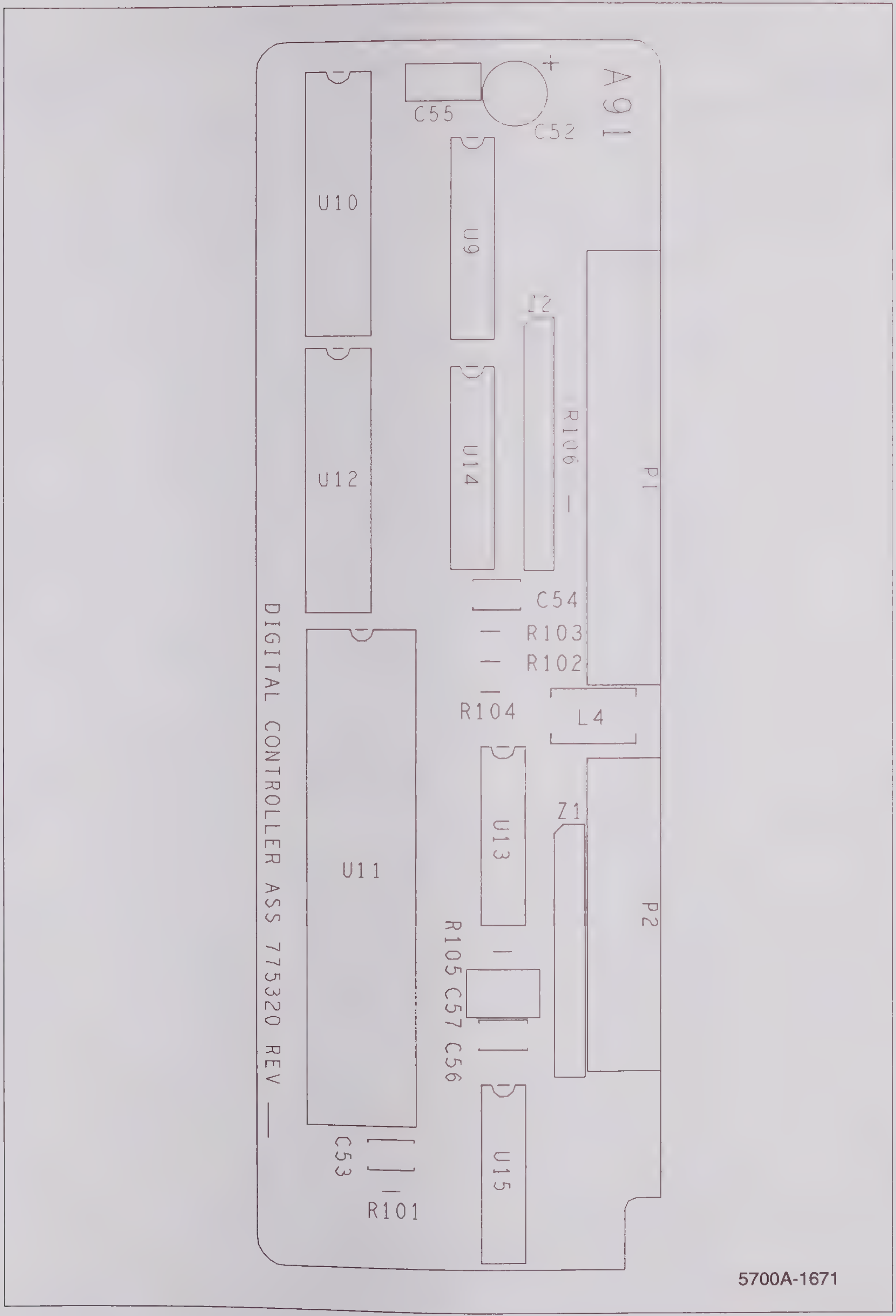

Figure 6-23. A16A1 Power Amplifier Digital Control SIP PCA

Table 6-22. A17 Regulator/Guard Crossing PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C2,C4,C6, C7,C9 C11,C12, C14-16,C19-23, C27,C28	CAP,AL,10UF,+-20%,50V,SOLV PROOF	799437 799437 799437 799437	18	
C3,C10,C18,C25	CAP,CER,0.05UF,+-20%,100V,Z5V	149161	4	
C5,C24,C29, C102	CAP,AL,22UF,+-20%,35V,SOLV PROOF	851766 851766	4	
C8,C13	CAP,TA,22UF,+-20%,25V	845149	2	
C17,C26,C65, C66	CAP,AL,10UF,+-20%,63V,SOLV PROOF	816843 816843	4	
C52,C53	CAP,CER,15PF,+-20%,50V,C0G	697524	2	
C54,C56,C59, C60,C101 C104-107,C109,C110, C112-114	CAP,POLYES,0.1UF,+-10%,50V	649913 649913 649913 649913	14	
C55,C58	CAP,TA,10UF,+-20%,10V	714766	2	
C57	CAP,TA,47UF,+-20%,10V	733246	1	
C61,C62	CAP,CER,22PF,+-5%,50V,C0G	714550	2	
C63,C64	CAP,CER,100PF,+-2%,50V,T2J	362665	2	
C67-70	CAP,TA,22UF,+-20%,25V	357780	4	
CR1-34	DIODE,SI,100 PIV,1 AMP	742874	34	
CR35	* DIODE,SI,SCHOTTKY,40V,DO-34	313247	1	
CR36	THYRISTOR,SI,SCR,VBO=200V,8.0A	634147	1	
F1	FUSE,8X8.5MM,3.15A,250V,SLOW,RADIAL	832253	1	
H19-22	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
H45-48	SCREW,PH,P,LOCK,SS,6-32,.500	320051	4	
H49-52	HEAT DIS ACC,NYL,TO-3	853952	4	
H53-60	NUT,EXT LOCK,STL,6-32,.344OD	152819	8	
J801,J802	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
L51	CHOKE, 3 TURN	452888	1	
L53,L54	CHOKE,2TURN	417196	2	
MP1,MP5,MP13	HEAT DIS,PRESS ON,TO-5	418384	3	
MP2-4,MP9, MP37	HEAT DIS,PWB MT,.75X.50X.50,TO-220	816587	5	
MP6-8,MP11	HEAT DIS,HORIZ,1.88X1.40X1.25,TO-3	643593	4	
MP10	HEAT DIS,SNAP ON,.75,TO-5	853283	1	
MP12	HEAT DIS,CLIP,1.00,1.18,.50,TO-220	643353	1	
MP14	HEAT DIS,VERT,1.00X.31X.81,TO-220	853395	1	
MP35,MP36	EJECTOR,PWB,NYLON	494724	2	
MP38	RIVETED,VOLTAGE REGULATOR AIR DUCT	883835	1	
MP39-42	INSUL PT,TO-3,SI,1.650,1.140	473165	4	
MP59-62	INSUL PT,TRANSISTOR MOUNT,DAP,TO-5	152207	4	
MP71,MP72	PAD, ADHESIVE	735365	2	
Q1	* TRANSISTOR, SI, BV=60V, 65W, T0-220	559989	1	
Q2	* TRANSISTOR,SI,BV=60V,65W,TO-220	386128	1	
R1,R4	RES,MF,113,+-0.1%,0.125W,100PPM	484238	2	
R02,R8	RES,MF,2.67K,+-1%,0.5W,100PPM	161430	2	
R5,R11	RES,MF,203,+-0.1%,.125W,100PPM	851191	2	
R6	RES,MF,2.61K,+-0.1%,0.125W,100PPM	851571	1	
R10	RES,MF,2.67K,+-0.1%,0.125W,25PPM	340596	1	
R13	RES,CF,10,+-5%,O.25W	340075	1	
R14,R18	RES,MF,150,+-0.1%,0.125W,100PPM	832360	2	
R15,R17	RES,MF,5.11K,0.1%,0.5W,100PPM	832378	2	
R19	RES,CC,3K,+-5%,0.5W	109090	1	
R20,R58	RES,CF,3K,+-5%,0.25W	441527	2	
R52	RES,MF,1K,+-1%,0.125W,100PPM	168229	1	
R53	RES,CF,10M,+-5%,.25W	875257	1	

Table 6-22. A17 Regulator/Guard Crossing PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
R54	RES,CF,1.8K,+-5%,0.25W	441444	1	
R56	RES,CF,150,+-5%,0.25W	343442	1	
R57	RES,CF,100,+-5%,0.25W	348771	1	
R60,R61	THERMISTOR,DISC,POS,100,+-20%,25C	851303	2	
SW51	SWITCH,PUSHBUTTON,SPST,MOMENTARY	782656	1	
T51	RF TRANSFORMER, 8 MHZ	813477	1	
TP1,TP4,TP6, TP8-010,TP12, TP55 TP58	JUMPER,WIRE,NONINSUL,0.200CTR	816090 816090 816090	9	
U1,U5,U10	* IC,VOLT REG,HIGH VOLTAGE	723445	3	
U2,U4	* IC,VOLT REG,FIXED,+15 VOLTS,1.5 AMPS	413187	2	
U3,U9	* IC,VOLT REG,FIXED,-15 VOLTS,1.5 AMPS	413179	2	
U6	* IC,VOLT REG,ADJ,POS,LOW DROPOUT	851717	1	
U7	* IC,VOLT REG,ADJ,NEG,LOW DROPOUT	851720	1	
U8,U11	* IC,VOLT REG,FIXED,+5 VOLTS,1.0 A,TO-3	327981	2	
U12	* IC,VOLT REG,FIXED,-5 VOLTS,1.5 AMPS	394551	1	
U13	* IC,VOLT REG,ADJ,-1.2 TO 47V,TO-39	845276	1	
U51	* IC,CMOS,HEX INVERTER,UNBUFFERED	741199	1	
U52	* IC,CMOS,OCTL LINE DRVR W/3-ST OUT	741892	1	
U53,U54	* IC,CMOS,3-8 LINE DECODER/DEMUX	799478	2	
U55	* IC,CMOS,OCTAL BUS TRANSCEIVER	722017	1	
U56	* IC,CMOS,8-BIT MPU,2.0 MHZ,256 BYT RAM	876326	1	
U57	* IC,TTL,DUAL AND DRVR W/OPEN COLLECTOR	393959	1	
U58	* IC,CMOS,PAL,PROG,5700A/5720A,DIP,U058	601955	1	
U59,U63	* IC,CMOS,14 STAGE BINARY COUNTER	807701	2	
U60	* IC,VOLT SUPERVISOR,4.55V SENSE INPUT	780577	1	
U62	* IC,CMOS,8K X 8 STAT RAM,120 NSEC	783332	1	
U64	* EPROM, PROGRAMMED, OTP, 5700A INGARD, U064	600137	1	
VR1,VR3	* ZENER,UNCOMP,43V,5%,3MA,0.5W	851584	2	
VR2,VR4	* ZENER,UNCOMP,10.0V,5%,12.5MA,0.4W	246611	2	
VR5,VR6	* ZENER,UNCOMP,5.6V,5%,220.0MA,5.0W	454553	2	
X1	SOCKET,IC,24 PIN	812198	1	
X3	SOCKET,IC,28 PIN	448217	1	
Y51	CRYSTAL,4.9152 MHZ,+/- 0.005%,HC-18/U	800367	1	
Y52	CRYSTAL,8.00MHZ QUARTZ HC-18U	707133	1	
Z1,Z3	RES,CERM,SIP,8 PIN,4 RES,10K,+-2%	513309	2	
Z2	RES,CERM,SIP,10 PIN,5 RES,10K,+-2%	529990	1	
Z51	RES,CERM,DIP,16 PIN,15 RES,10K,+-5%	355305	1	
Z52	RES,CERM,SIP,8 PIN,4 RES,4.7K,+-2%	573881	1	
Z53,Z54	RES,CERM,SIP,10 PIN,5 RES,33,+-2%	622761	2	

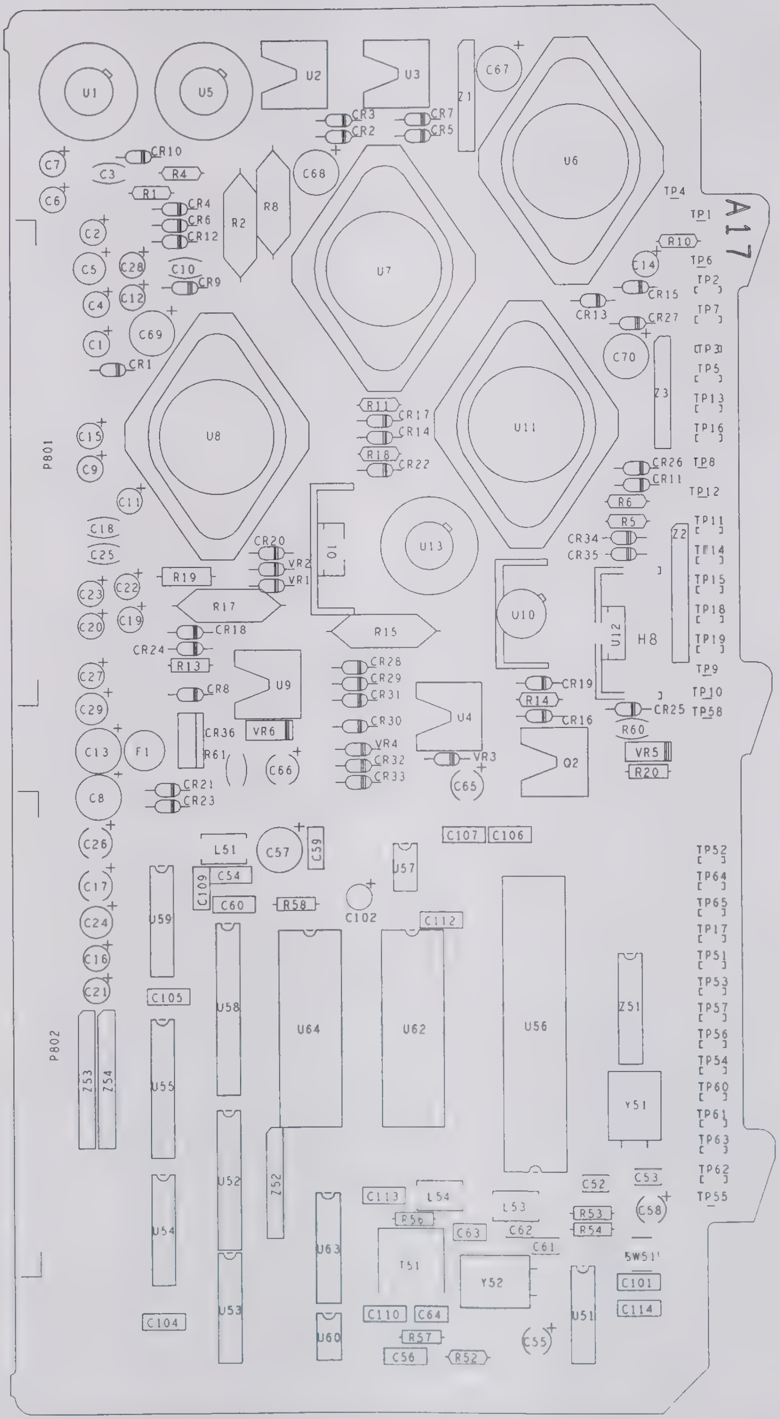

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Figure 6-24. A17 Regulator/Guard Crossing PCA

Table 6-23. A18 Filter/PA Supply PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C10,C17	CAP,POLYES,0.22UF,+-5%,50V	747519	3	
C2,C3	CAP,AL,6800UF,+-20%.25V	782466	2	
C4,C6	CAP,AL,1000UF,+-20%,50V,SOLV PROOF	782391	2	
C5,C19	CAP,AL,2200UF,+-20%,25V,SOLV PROOF	782383	2	
C7-9,C18	CAP,AL,330UF,+-20%,100V,SOLV PROOF	816785	4	
C11	CAP,AL,220UF,+-20%,25V,SOLV PROOF	816793	1	
C12,C22	CAP,AL,22UF,+-20%,35V	817056	2	
C13-16	CAP,AL,3300UF,+-20%,50V	782458	4	
C20	CAP,AL,10UF,+-20%,63V,SOLV PROOF	816843	1	
C21	CAP,AL,470UF,+-20%,50V,SOLV PROOF	747493	1	
C23,C209,C210	CAP,POLYES,1UF,+-10%,50V	733089	3	
C201,C203, C204, C206	CAP,AL,47UF,+-20%,400V,SOLV PROOF	782532 782532	4	
C202,C205	CAP,AL,3.3UF,+30-20%,450V	782524	2	
C207,C208	CAP,AL,100UF,+-20%,16V,SOLV PROOF	816850	2	
C211,C212	CAP,CER,100PF,+-5%,50V,C0G	831495	2	
CR1,CR2,CR04, CR5 CR8,CR10, CR12,CR13	DIODE,SI,150 PIV,5.0 AMP	523720 523720 523720	8	
CR3,CR14	DIODE,SI,RECT,BRIDGE,BV=100V,IO=2A	392910	2	
CR6,CR7	DIODE,SI,RECT,BRIDGE,BV=200V,I.5A	296509	2	
CR9,CR16,CR18	DIODE,SI,100 PIV,1 AMP	742874	3	
CR11,CR15, CR17	DIODE,SI,RECT,BRIDGE,BV=50V,IO=3A	586115 586115	3	
CR19	* THYRISTOR,SI,TRIAC,VBO=200V,8.0A	413013	1	
CR201,CR203, CR208,CR210, CR234,CR235, CR239,CR243,	DIODE,SI,400 PIV,1 AMP	831586 831586 831586 831586	8	
CR205,CR217, CR218,CR220, CR221,CR223, CR224,CR227, CR228,CR240, CR247,CR248	DIODE,SI,1K PIV,1.0 AMP	707075 707075 707075 707075 707075 707075	12	
CR209,CR236	* DIODE,SI,N-JFET,CURRENT REG,IF	334839	2	
CR222	DIODE,SI,RECT,BRIDGE,BV=800V,IO=1A	341016	1	
CR244,CR251-253	* DIODE,SI,BV=75V,IO=150MA,500MW *	659516 659516	4	
F1,F2,F8	FUSE,8X8.5MM,1.6A,250V,SLOW,RADIAL	816488	3	
F3-5,F7,F9	FUSE,8X8.5MM,0.5A,250V,SLOW,RADIAL	831990	5	
F6	FUSE,8X8.5MM,0.315A,250V,SLOW,RADIAL	832337	1	
F201-204	FUSE,8X8.5MM,0.2A,250V,SLOW,RADIAL	851949	4	
H6-9	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
J201,J202	JUMPER,REC,2 POS,.100CTR,.025	757294	2	
K201	RELAY,ARMATURE,2 FORM C,5V	733063	1	
MP2	FOOT,RUBBER,ADHES,BLK,.50 SQ,.12 THK	543488	1	
MP3	HEAT DIS,PRESS ON,TO-5	418384	1	
MP4,MP5	EJECTOR,PWB,NYLON	494724	2	
MP10	INSUL PT,TRANSISTOR MOUNT,DAP,TO-5	152207	1	
MP201,MP202	HEADER,1 ROW,.100CTR,2 PIN	643916	2	
MP203-206	HEAT DIS,VERT,1.00X1.50X.375,T0-220	816546	4	
MP207-210	INSUL PT,POWER,SI,.750,.500	534453	4	
MP211-214	WASHER,SHOULDER,TEFLON,#4	844824	4	
MP215-218	SCREW,PH,P,LOCK,SS,4-40,.250	256156	4	
MP219-222	NUT,HEX,STL,4-40	110635	5	
P901,P902	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	

Table 6-23. A18 Filter/PA Supply PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
Q201,Q202	* TRANSISTOR,SI,N-MOS,40W,500V,T0-220	782540	2	
Q203,Q206	* TRANSISTOR,SI,PNP,350V,0.6W,SEL,TO-92	650846	2	
Q204,Q209, Q210, Q212	* TRANSISTOR,SI,P-MOS,500V,TO-92 *	782508 782508	4	
Q205,Q207, Q208, Q213	* TRANSISTOR,SI,N-DMOS,500V,TO-92 *	782490 782490	4	
Q211,Q214	* TRANSISTOR,SI,NPN,350V,0.625MW,TO-92	853994	2	
Q215,Q216	* TRANSISTOR,SI,P-MOS,POWER,500V	782482	2	
Q217	* TRANSISTOR,SI,100V,10W,TO-202	943803	1	
Q218	* TRANSISTOR,SI,NPN,SMALL SIGNAL	698225	1	
Q219	* TRANSISTOR,SI,PNP,40V,0.35W,TO-92	698233	1	
R1	RES,CC,560,+-5%,1W	266361	1	
R2-5	RES,CC,20K,+-5%,0.5W	109041	4	
R201,R244	RES,CF,8.2,+-5%,0.25W	442269	2	
R202,R243	RES,CF,5.1,+-5%,0.25W	441287	2	
R203,R241, R256, R257	RES,CF,9.1K,+-5%,0.25W	706663 706663	4	
R204,R253	RES,CF,1.5,+-5%,0.25W	732800	2	
R205,R216, R229, R240	RES,CC,560K,+-10%,0.5W	108795 108795	4	
R206,R239	RES,CF,1M,+-5%,0.25W	649970	2	
R207,R209, R237, R238	RES,CC,470K,+-10%,0.5W	108290 108290	4	
R208,R210, R235, R236	RES,CC,220K,+-10%,1W	109652 109652	4	
R211	RES,CF,47,+-5%,0.25W	822189	1	
R212,R220, R222, R231, R242	RES,CF,33K,+-5%,0.25W	733667 733667 733667	5	
R213,R217,R218, R230, R232,R245, R249	RES,CF,10K,+-5%,0.25W	697102 697102 697102	7	
R214,R233	RES,CF,200K,+-5%,0.25W	681841	2	
R215,R234	RES,CC,330,+-10%,0.5W	108589	2	
R221,R250	RES,CF,82K,+-5%,0.25W	655027	2	
R225	RES,CF,100K,+-5%,0.25W	348920	1	
R226,R248	RES,MF,3.16K,+-1%,0.125W,100PPM	235291	2	
R228,R247	RES,CF,100K,+-5%,0.25W	658963	2	
R246,R251	RES,CF,4.7K,+-5%,0.25W	721571	2	
R252	RES,CF,300K,+-5%,0.25W	732818	1	
R254,R255	RES,CC,27,+-5%,0.5W	260984	2	
RT1,RT2	THERMISTOR,DISC,POSITIVE,50,+-30%	816140	2	
S201	SWITCH,SLIDE,DPDT	436691	1	
TP201	SOCKET,SINGLE,PWB,FOR 0.080 PIN	170480	1	
TP204	SOCKET,SINGLE,PWB,FOR 0.080 PIN	149120	1	
TP1-22,TP203, TP205-212	JUMPER,WIRE,NONINSUL,0.200CTR	816090 816090	31	
U1	* IC, VOLT REG,FIXED,-5 VOLTS,0.5 AMPS	816322	1	
U2	* IC,VOLT REG,FIXED,+5 VOLTS,0.1 AMPS	816355	1	
U3	* IC,VOLT REG,FIXED,-18 VOLTS,1.5 AMPS	845474	1	
U201	* IC,COMPARATOR,QUAD,14 PIN DIP	387233	1	
VR20,VR21	* ZENER,UNCOMP,82.0V,5%,1.5MA,0.5W	844977	2	
VR202,VR213, VR233,VR242	* ZENER,UNCOMP,10.0V,5%,12.5MA,0.4W *	810267 810267	4	
VR206,VR207, VR218,VR228, VR237,VR238	* ZENER,UNCOMP,10.0V,5%,20.0MA,0.5W * *	820480 820480 820480	6	

Table 6-23. A18 Filter/PA Supply PCA (cont)

Reference Designator		Description	Fluke Stock No	Tot Qty	Notes
VR211,VR217, VR227,VR231	* *	ZENER,UNCOMP,140.0V,5%,1.8MA,1.0W	340703 340703	4	
VR212,VR216, VR226,VR232	* *	ZENER,UNCOMP,180V,2%,0.68MA,0.4W	816348 816348	4	
VR214,VR230, VR246,VR247	* *	ZENER,UNCOMP,56V,5%,2.2MA,0.4W	832568 832568	4	
VR215,VR219, VR225,VR229	* *	ZENER,UNCOMP,200.0V,5%,5.0MA,5.0W	386839 386839	4	
VR245	*	ZENER,UNCOMP,3.3V,5%,20.0MA,0.4W	820423	1	
Z1-3		RES,CERM,SIP,10 PIN,5 RES,10K,+-2%	529990	3	
Z201		RES,CERM,SIP,6 PIN,5 RES,100K,+-2%	412726	1	

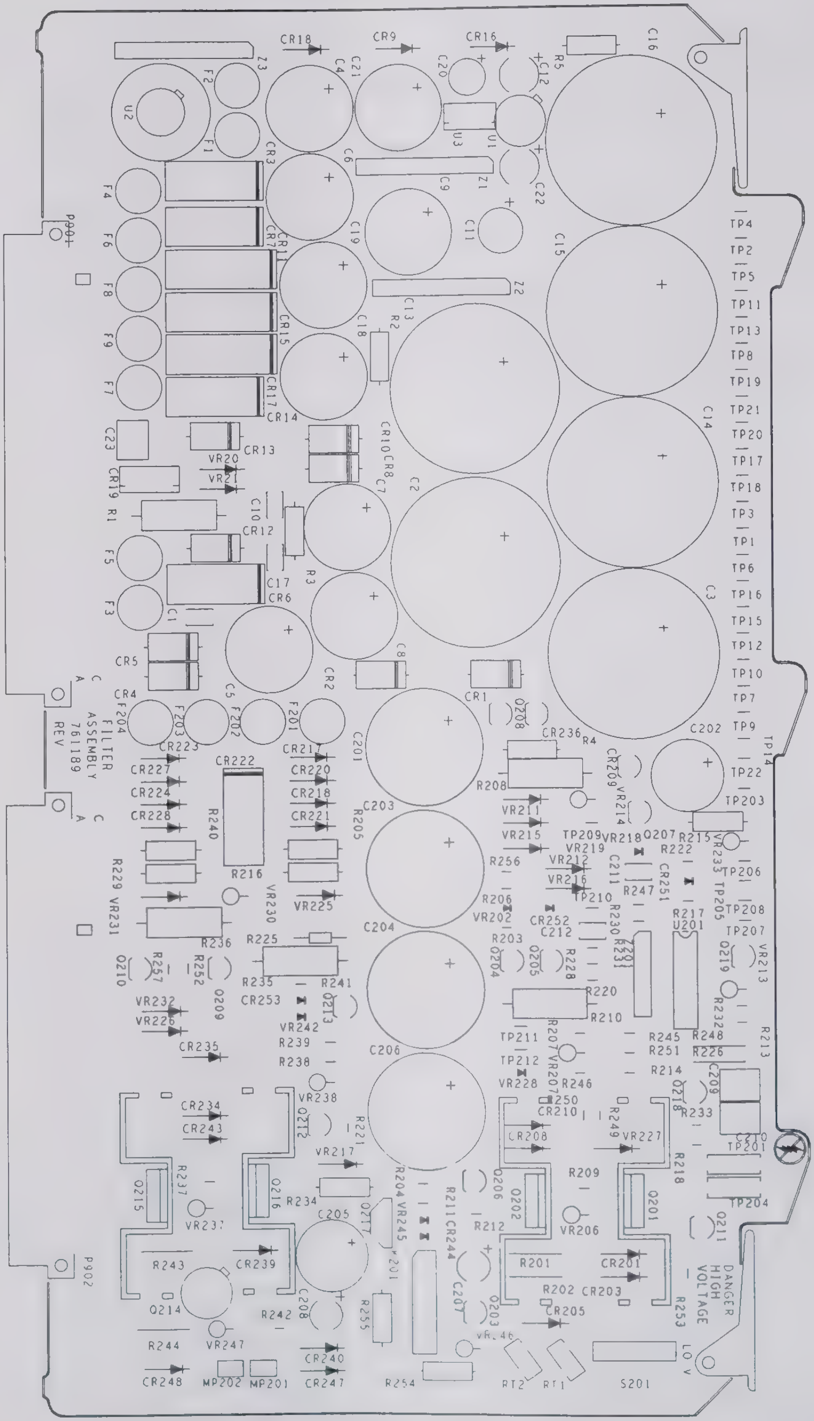


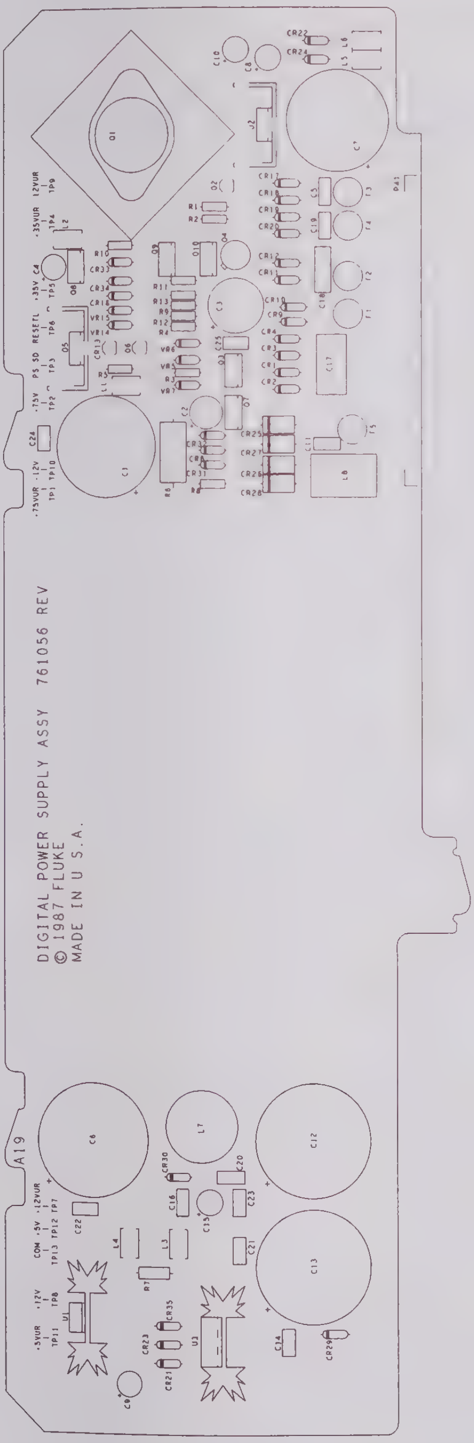
Figure 6-25. A18 Filter/PA Supply PCA

Table 6-24. A19 Digital Power Supply PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1	CAP,AL,470UF,+-20%,160V	816835	1	
C2	CAP,AL,10UF,+-20%,160V,SOLV PROOF	817064	1	
C3	CAP,AL,330UF,+-20%,100V,SOLV PROOF	816785	1	
C4,C9	CAP,AL,10UF,+-20%,63V,SOLV PROOF	816843	2	
C5,C11	CAP,CER,0.10UF,+-20%,50V,X7R	853650	2	
C6	CAP,AL,10000UF,+-20%,25V	816819	1	
C7	CAP,AL,6800UF,+-20%.25V	782466	1	
C8	CAP,AL,2.2UF,+-20%,50V,SOLV PROOF	816868	1	
C10	CAP,AL,22UF,+-20%,35V	817056	1	
C12,C13	CAP,AL,22000UF,+-20%,16V	822379	2	
C14,C16,C19-23	CAP,CER,0.22UF,+-20%,50V,X7R	853648	7	
C15	CAP,AL,100UF,+-20%,16V,SOLV PROOF	816850	1	
C17	CAP,POLYPR,0.047UF,+-10%,630V	500827	1	
C18	CAP,POLYPR,0.047UF,+-10%,160V	446773	1	
C24,C25	CAP,CER,0.022UF,+80-20%,500V,Z5U	740340	2	
CR1-4,CR9-12	DIODE,SI,200 PIV,1.0 AMP	586644	8	
CR8,CR16, CR21-24,CR29-34	DIODE,SI,100 PIV,1 AMP	742874 742874 742874	12	
CR13	* DIODE,SI,N-JFET,CURRENT REG,IF	852137	1	
CR17-20	DIODE,SI,50 PIV,1.0 AMP	379412	4	
CR25-28	DIODE,SI,150 PIV,5.0 AMP	523720	4	
CR35	* DIODE,GER,BV=66V,IO=50MA	180505	1	
F1	FUSE,8X8.5MM,0.315A,250V,SLOW,RADIAL	832337	1	
F2	FUSE,8X8.5MM,0.125A,250V,SLOW,RADIAL	832261	1	
F3,F4	FUSE,8X8.5MM,2A,250V,SLOW,RADIAL	806331	2	
F5	FUSE,8X8.5MM,3.15A,250V,SLOW,RADIAL	832253	1	
H2	SCREW,PH,P,LOCK,SS,4-40,.375	256164	1	
H3,H4	HEAT DIS,CLIP,1.00,1.18,.50,TO-220	643353	2	
H5	HEAT DIS,VERT FINS,TO-3	342675	1	
H6,H7	RIVET,S-TUB,OVAL,AL,.087,.343	838458	2	
H11	SCREW,PH,P,LOCK,SS,4-40,.437	403782	1	
L1-6	CHOKE,6TURN	320911	6	
L7	INDUCTOR, 33UH	813485	1	
L8	TRANSFORMER, PULSE	660589	1	
M1,M2	FOOT,RUBBER,ADHES,GRY,.44 DIA,.20 THK	358341	2	
MP8,MP27	NUT,HEX,STL,4-40	110635	2	
MP9,MP10	NUT,EXT LOCK,STL,6-32,.344OD	152819	2	
MP11,MP12	GROMMET,SLOT,RUBBER,.438,.062	853291	2	
MP13,MP14	EJECTOR,PWB,NYLON	494724	2	
MP15,MP26	HEAT DIS,VERT,1.00X1.375X0.50,TO-220	831099	2	
MP16	HEAT,DIS,ACC,NYL,TO-3	851907	1	
MP21	INSUL PT,POWER,SI,.750,.500	534453	1	
MP24	INSUL PT,TO-3,SI,1.650,1.140	473165	1	
MP25	INSUL PT,TRANSISTOR MOUNT,DAP,TO-5	152207	1	
MP28,MP29	SCREW,PH,P,LOCK,STL,6-32,.250	152140	2	
MP30,MP31	SPACER,SWAGE,.250 RND,BR,6-32,.125	435578	2	
P41	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	1	
Q1	* TRANSISTOR,SI,BV=200V,80W,TO-3	261347	1	
Q2,Q6	* TRANSISTOR,SI,NPN,HI-VOLTAGE	370684	2	
Q3,Q7-10	* TRANSISTOR,SI,300V,10W,TO-202	107646	5	
Q4	* TRANSISTOR,SI,VCB=200V,1W,TO-3	276899	1	
Q5	* TRANSISTOR,SI,BV=60V,65W,TO-220	386128	1	
R1	RES,CF,5.1,+-5%,0.25W	441287	1	
R2	RES,CF,2K,+-5%,0.25W	441469	1	

Table 6-24. A19 Digital Power Supply PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
R3,R12	RES,CF,100K,+-5%,0.25W	348920	2	
R4	RES,CC,4.7K,+-5%,0.25W	148072	1	
R5	RES,CF,12,+-5%,0.25W	442178	1	
R6	RES,CC,10K,+-10%,2W	110106	1	
R7	RES,CC,2,+-5%,0.5W	218735	1	
R8	RES,CF,120K,+-5%,0.25W	441386	1	
R9,R11	RES,CF,33K,+-5%,0.25W	348888	2	
R10	RES,CF,51K,+-5%,0.25W	376434	1	
R13	RES,CC,10K,+-5%,0.25W	148106	1	
TP1-5,TP8,TP10, TP12,TP13	JUMPER,WIRE,NONINSUL,0.200CTR	816090 816090	9	
U1	* IC,VOLT REG,FIXED,+12 VOLTS,1.5 AMPS	413195	1	
U2	* IC,VOLT REG,FIXED,-12 VOLTS,1.5 AMPS	381665	1	
U3	* IC,VOLT REG,FIXED,5 VOLTS,2 AMPS	816918	1	
VR5	* ZENER,UNCOMP,6.2V,5%,20.0MA,0.4W	325811	1	
VR6	* ZENER,UNCOMP,36.0V,5%,3.4MA,0.4W	186163	1	
VR7	* ZENER,UNCOMP,39.0V,5%,3.2MA,0.4W	831248	1	
VR14,VR15	* ZENER,UNCOMP,18.0V,5%,7.0MA,0,4W	327973	2	



5700A-1604

Figure 6-26. A19 Digital Power Supply PCA

Table 6-25. A20 CPU PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
BT1	BATTERY,LITHIUM,3.0V,0.560AH	821439	1	
C1	CAP,TA,220UF,+-20%,10V	474288	1	
C2-4,C6,C101-106,C108-111, C113,C115-120, C122-133,C143-145,C152	CAP,POLYES,0.1UF,+-10%,50V	649913 649913 649913 649913 649913	37	
C5	CAP,TA,15UF,+-20%,20V	807610	1	
C8-11	CAP,CER,22PF,+-2%,50V,C0G	714832	4	
C12,C13	CAP,POLYES,0.22UF,+-10%,50V	706028	2	
C17	CAP,AL,47UF,+-20%,35V,SOLV PROOF	643312	1	
C80	CAP,CER,0.22UF,+80-20%,50V,Z5U	649939	1	
C81,C82	CAP,CER,120PF,+-5%,50V,C0G	721142	2	
C100	CAP,TA,2.2UF,+-20%,16V	706804	1	
CR1	LED, RED,T1/T1-3/4,5MM LEAD SPACING	723486	1	
CR2,CR3,CR7	DIODE,SI,100 PIV,1 AMP	742874	3	
CR4-6,CR8	* DIODE,SI,SCHOTTKY,40V,DO-34	313247	4	
H3-6	RIVET,S-TUB,OVAL,AL,.087,.343	838458	4	
L80,L81	CHOKE, 3 TURN	452888	2	
MP1,MP2	EJECTOR,PWB,NYLON	494724	2	
MP3,MP4	FOOT,RUBBER,ADHES,GRY,.44 DIA,.20 THK	358341	2	
MP7	PAD, ADHESIVE	735365	1	
MP8	PAD, ADHESIVE	735365	1	
P61,P62	CONN,DIN41612,TYPE C,RT ANG,64 PIN	807800	2	
R1,R3	RES,CF,470,+-5%,0.25W	343434	2	
R4	RES,CF,10M,+-5%,.25W	875257	1	
R5	RES,CF,1.8K,+-5%,0.25W	441444	1	
R6	RES,CF,6.2K,+-5%,0.25W	442368	1	
R51-54	RES,MF,5.11K,+-1%,0.125W,100PPM	294868	4	
R55	RES,MF,10K,+-1%,0.125W,100PPM	168260	1	
R56,R57	RES,MF,1K,+-1%,0.125W,100PPM	168229	2	
R58,R59	RES,MF,39.2K,+-1%,0.125W,25PPM	312207	2	
R60,R61	RES,MF,1M,+-1%,0.125W,100PPM	268797	2	
R82	RES,CF,150,+-5%,0.25W	343442	1	
SW1	SWITCH,PUSHBUTTON,SPST,MOMENTARY	782656	1	
T51	RF TRANSFORMER, 8 MHZ	813477	1	
TP1,TP3-12	JUMPER,WIRE,NONINSUL,0.200CTR	816090	11	
U1	* IC,VOLT SUPERVISOR,4.55V SENSE INPUT	780577	1	
U2	* IC,LSTTL,HEX INVERTER W/OPEN COLLECT	394536	1	
U3	* IC,CMOS,HEX INVERTER,UNBUFFERED	741199	1	
U4,U11	* IC,CMOS,14 STAGE BINARY COUNTER	807701	2	
U5	* IC,CMOS,PAL,PROGRAMD,35NS,5700A-90760	845271	1	
U6	* IC,CMOS,PAL,PROGRAMD,25NS,5700A-90761	845250	1	
U8	* IC,CMOS,16 BIT MPU,8 MHZ,DIP	816926	1	
U9	* IC,CMOS,QUAD 2 INPUT OR GATE	817312	1	
U10	* IC,CMOS,PAL,PROGRAMD,35NS,5700A-90762	845268	1	
U13	* IC,CMOS,32KX8 EEPROM,250NS	875260	1	
U15	* EPROM, PROGRAMMED 27010		1	1
U16	* EPROM, PROGRAMMED 27010		1	2
U17	* EPROM, PROGRAMMED 27010		1	3
U18	* EPROM, PROGRAMMED 27010		1	4
U23	* EPROM, PROGRAMMED 27010		1	5
U24	* EPROM, PROGRAMMED 27010		1	6
U19-22	* IC,CMOS,32K X 8 STATIC RAM,120	800250	4	
U25,U27-29	* IC,CMOS,OCTL LINE DRVR W/3-ST	741892	4	
U26,U30	* IC,CMOS,OCTAL BUS TRANSCEIVER	722017	2	

Table 6-25. A20 CPU PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
U31	* IC,CMOS,DUAL CHANNEL UART (DUART)	799494	1	
U32	* IC,TTL,DUAL AND DRVR W/OPEN COLLECTOR	393959	1	
U33	* IC,CMOS,CLOCK CALENDAR	807693	1	
U52	* IC,OP AMP,QUAD,14 PIN DIP	402669	1	
XU5,XU6,XU10	SOCKET,IC,24 PIN	812198	3	
XU8	SOCKET,IC,64 PIN	483842	1	
XU13	SOCKET,IC,28 PIN	448217	1	
XU15-24	SOCKET,IC,32 PIN	807156	10	
Y1	CRYSTAL,7.3728MHZ,+-1,%,HC-18U	742049	1	
Y3	CRYSTAL,32.768KHZ,+-5PPM	811943	1	
Z1	RES,CERM,DIP,16 PIN,15 RES,3.3K,+-5%	837666	1	
Z2,Z3	RES,CERM,DIP,16 PIN,15 RES,4.7K,+-5%	416834	2	
Z4	RES,CERM,SIP,10 PIN,5 RES,10K,+-2%	529990	1	
Z5	RES,CERM,DIP,14 PIN,13 RES,100K,+-2%	404624	1	

1. For 5720A order Fluke PN 600764.
   For 5700A Series I order Fluke PN 761262.
   For 5700A Series II order Fluke PN 600798.
2. For 5720A order Fluke PN 600767.
   For 5700A Series I order Fluke PN 761361.
   For 5700A Series II order Fluke PN 600806.
3. For 5720A order Fluke PN 600772.
   For 5700A Series I order Fluke PN 761379.
   For 5700A Series II order Fluke PN 600815.
4. For 5720A order Fluke PN 600775.
   For 5700A Series I order Fluke PN 775247.
   For 5700A Series II order Fluke PN 600822.
5. For 5720A order Fluke PN 600780.
   For 5700A Series II order Fluke PN 6007830.
6. For 5720A order Fluke PN 600783.
   For 5700A Series II order Fluke PN 600848.

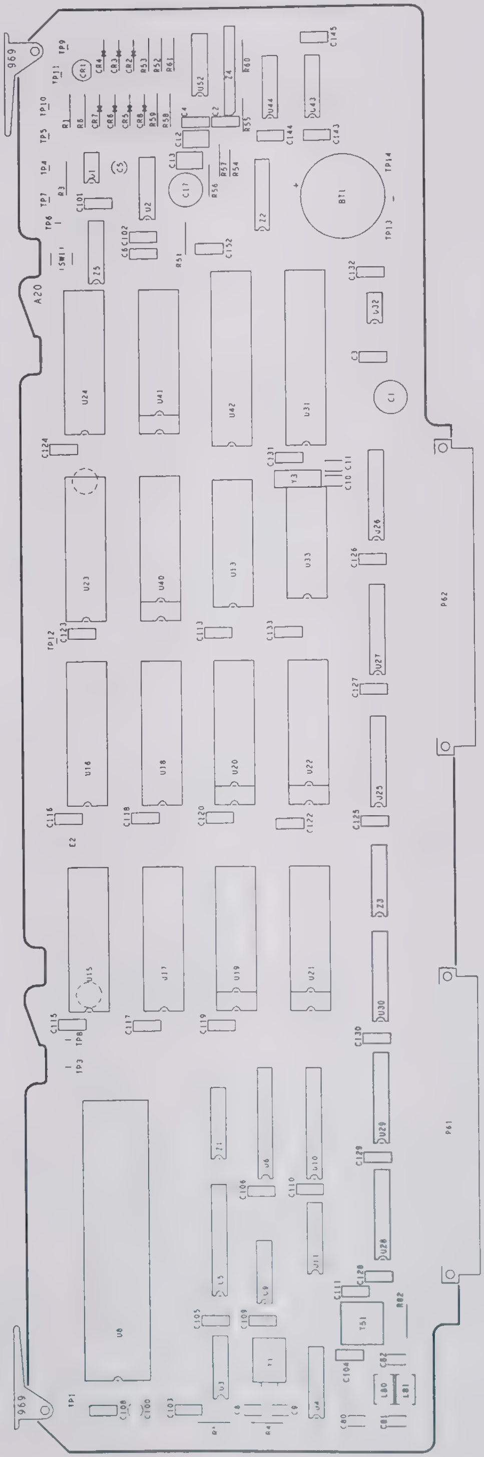


Figure 6-27. A20 CPU PCA

Table 6-26. A21 Rear Panel PCA

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
C1,C3,C5	CAP,CER,330PF,+-5%,50V,C0G	697441	3	
C4,C21,C22,C24-32,C34,C36,C37,C40-45,C48,C49	CAP,POLYES,0.1UF,+-10%,50V	649913 649913 649913	23	
C6,C7	CAP,CER,0.22UF,+80-20%,50V,Z5U	649939	2	
C8	CAP,CER,4700PF,+-20%,100V,C0G	743427	1	
C9	CAP,CER,470PF,+-10%,50V,C0G	733071	1	
C10,C70	CAP,TA,68UF,+-20%,15V	193615	2	
C11-15	CAP,TA,10UF,+-20%,25V	714774	5	
C16	CAP,TA,10UF,+-20%,35V	816512	1	
C33	CAP,TA,39UF,+-20%,20V	358234	1	
C46,C50	CAP,TA,1UF,+-20%,35V	697417	2	
C47	CAP,CER,33PF,+-2%,50V,C0G	715292	1	
C71	CAP,CER,47PF,+-20%,50V,C0G	706705	1	
CR1-6	* DIODE,SI,BV=75V,IO=150MA,500MW	203323	6	
F1,F2	FUSE,.095X.28,0.25A,125V,FAST,AXIAL	806737	2	
J1	CONN,MICRO-RIBBON,REC,PWB,24 PIN	851675	1	
J2	CONN,D-SUB,PWB,25 PIN	845214	1	
J3	CONN,D-SUB,PWB,15 SCKT	837336	1	
J4	CONN,D-SUB,PWB,15 PIN	837328	1	
J5,J6	CONN,COAX,BNC(F),PWB	479162	2	
J7	CONN,D-SUB,PWB,4 CAVITY,32 SCK	810846	1	
J8	HEADER,2 ROW,.100CTR,40 PIN	807453	1	
J9	HEADER,2 ROW,.100CTR,34 PIN	807446	1	
J11,J12	HEADER,1 ROW,.100CTR,3 PIN	837351	2	
K1,K4,K5,K7-12	RELAY,ARMATURE,2 FORM C,5V	733063	9	
K2,K3,K6	RELAY,ARMATURE,4 FORM C,5V,LATCH	715078	3	
L1	CHOKE,6TURN	320911	1	
MP1,MP2	SPACER,SWAGE,.250 RND,BR,6-32,.220	261727	2	
MP3-10	SPACER,SWAGE,.250 RND,BR,4-40,.234	385310	8	
MP21,MP22	SPACER,SWAGE,.250 RND,BR,6-32,.437	423806	2	
Q1,Q2	* TRANSISTOR,SI,N-CHAN,TO-92	832139	2	
R1	RES,MF,1K,+-1%,0.125W,100PPM	168229	1	
R2	RES,MF,332,+-1%,0.125W,100PPM	192898	1	
R3	RES,CF,5.1K,+-5%,0.25W	368712	1	
R4,R5,R12,R13,R16,R17	RES,CF,10K,+-5%,0.25W	348839 348839	6	
R6	RES,CF,15K,+-5%,0.25W	348854	1	
R7,R14	RES,CF,1K,+-5%,0.25W	343426	2	
R8,R9	RES,CF,200,+-5%,0.25W	441451	2	
R10	RES,CF,620,+-5%,0.25W	810408	1	
R11	RES,CC,1K,+-10%,1W	109371	1	
R20	RES,CF,200K,+-5%,0.25W	441485	1	
R22,R23	RES,MF,200,+-1%,0.125W,100PPM	245340	2	
S1	SWITCH,SLIDE,SPDT,LOW PROFILE	911250	1	
TP1-15	JUMPER,WIRE,NONINSUL,0.200CTR	816090	15	
U1	* IC,CMOS,OCTAL BUS TRANSCEIVER	722017	1	
U2	* IC,NMOS,GPIB ADAPTER	585240	1	
U3	* IC,LSTTL,OCTAL GPIB XCVR W/OPEN COL	585224	1	
U4	* IC,LSTTL,OCTAL IEEE-488 BUS TR	686022	1	
U5	* IC,CMOS,DUAL CHANNEL UART (DUART)	799494	1	
U6	* IC,TTL,QUAD RS232C LINE DRIVER	414052	1	
U7	* IC,TTL,QUAD RS232C LINE RECEIVER	524850	1	
U8	* IC,CMOS,PAL,PROGRAMD,35NS,5700A-90790	845255	1	
U9,U10	* IC,CMOS,OCTL D F/F W/3-STATE,+EDG TRG	585364	2	
U11,U12	* IC,CMOS,OCTL LINE DRVR W/3-ST OUT	741892	2	

Table 6-26. A21 Rear Panel PCA (cont)

Reference Designator	Description	Fluke Stock No	Tot Qty	Notes
U13	* IC,OP AMP,JFET INPUT,22V SUPPLY,DIP	832584	1	
U14	* IC,CMOS,PROGRMBL PERIPHERAL INTERFACE	780650	1	
U16,U17	* IC,BIMOS,8 CHNL HI-VOLT DRVR W/LATCH	782912	2	
U18	* IC,COMPARATOR,HI-SPEED,14 PIN	647115	1	
VR1,VR2	* ZENER,UNCOMP,3.3V,10%,20.0MA,0.4W	309799	2	
VR3	* ZENER,UNCOMP,4.7V,10%,20.0MA,0.4W	387084	1	
W1	CABLE, BOOST, B-OUT HIGH	802827	1	
W2	CABLE, BOOST, B-SENSE HIGH	802850	1	
W3	CABLE, BOOST HIGH VOLTAGE	802843	1	
X8	SOCKET,IC,24 PIN	812198	1	
Z1,Z2	RES,CERM,SIP,10 PIN,9 RES,4.7K,+-2%	484063	2	
Z4	RES,CERM,SIP,6 PIN,5 RES,4.7K,+-2%	494690	1	
Z5	RES,CERM,SIP,6 PIN,5 RES,10K,+-2%	500876	1	

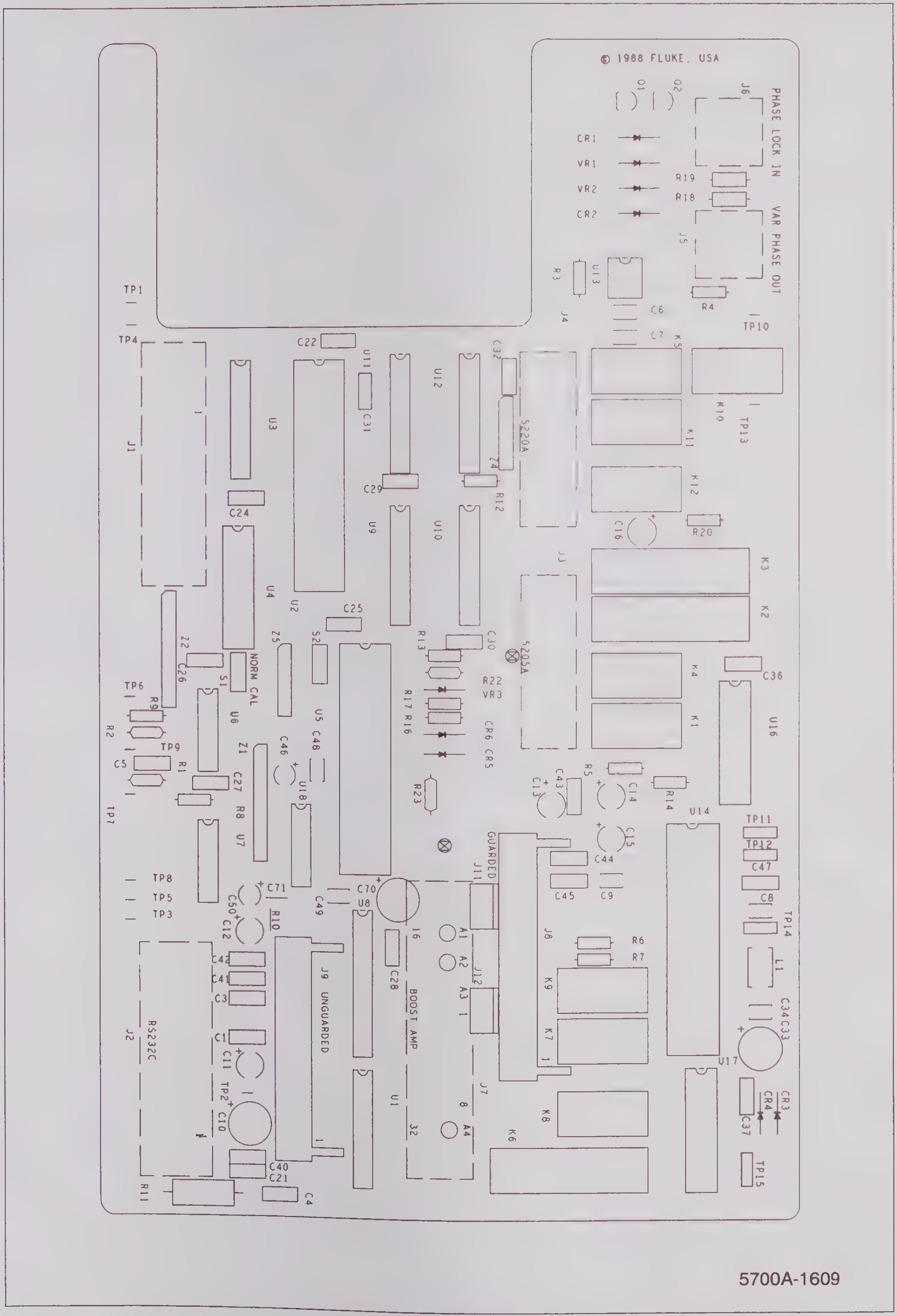


Figure 6-28. A21 Rear Panel PCA

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FAX: (201) 599-2093

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J/n H.R. Rasuna Said Kav. 3-4
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R.D.T Equipment & Sys, Ltd.
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FAX: 972-3-647-8908

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Viale Delle Industrie, 11
20090 Vimodrone (MI)
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FAX: 39-2-250-1645

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Shinbashi Bldg.
1-1-11 Hamamatsucho
Minato-ku, Tokyo 105
TEL: 81-3-3434-0188 or 0181
FAX: 81-3-3434-0170

Kenya
Walterfang
P.O. Box 14897
Nairobi, Kenya
TEL: 254-2
FAX: 254-2

Korea
B&P International Co., Ltd.
Geopung Town A-303
203-1 Nonhyun-Dong
Kangnam-Ku
Seoul 135-010
TEL: 82 12 546-1457
FAX: 82 12 546-1458

IL MYOUNG, INC.
Youngdong P.O. Box 1486
780-46, Yeogsam-Dong
Kangnam-Ku, Seoul
TEL: 82 2 552-8582-4
FAX: 82 2 553-0388

Kuwait
Yusuf A. Alghanim & Sons W.L.L.
P.O. Box 223 Safat
Alghanim Industries
Airport Road Shuwaikh
13003 Kuwait
TEL: 965-4842988
FAX: 965-4847244

Malaysia
CNN. SDN. BHD.
17D, 2nd Floor
Lebuhraya Batu Lancang
Taman Seri Damai
11600 Jelutong Penang
TEL: 60-4-657-9584
FAX: 60-4-657-0835

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Metro. Y Calibraciones Ind., S.A.
Diagonal No. 17 - 3 Piso
Col. Del Valle
C.P. 03100, Mexico D.F.
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FAX: 52-5-687-8695

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Afdeling Service
Science Park Einhoven 5108
5692 EC Son
TEL: 31-40-2678
FAX: 31-40-2678

New Zealand
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Private Bag 41904,
St. Lukes, 2 Wagener Place
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N-0601 Oslo
TEL: 47-22-653400
FAX: 47-22-653407

Pakistan (Philips)
Philips Elec. Ind. of Prof. Sys. Div.
Islamic Cham. of Commerce
St-2/A, Block 9, KDA Scheme 5,
Clifton, Karachi-75600
TEL: 92-21-587-4641 or 4649
FAX: 92-21-577-0348

Peru
Impor. & Repres. Electronicas
S.A., JR. Pumacahua 955
Lima 11
TEL: 51-14-23-5099
FAX: 51-14-31-0707

Philippines
Spark Electronics Corp.
P.O. Box 610, Greenhills
Metro Manila 1502
TEL: 63-2-700-621
FAX: 63-2-721-0491 or 700-709

Poland
Elec. Instr. Srv. Philips Cons.
UL. Malechowska 6
60 188 Poznan
TEL: 48-61-681998
FAX: 48-61-682256

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Fluke Iberica S.L.
Sasles Y Services Dept
Campo Grande 35 - 7b
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FAX: 351-1-795-1713

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Str. Transilvaniei Nr. 24
70778 Bucharest - I
TEL: 40-1-614-3597 or 3598
FAX: 40-1-659-4468

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FAX: 7-95-212-3838

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FAX. 966-2-661-0558

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South Africa
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Spescom Park
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Halfway House, Midrand 1685
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FAX: 27-11-805-1192

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28760-Tres Cantos
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Fluke Sverige AB, (CSS)
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S-164 94 Kista
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FAX: 46-8-751-0480

Switzerland
Fluke Switzerland AG, (CSS)
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Switzerland
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FAX: 41-1-730-3932

Taiwan
Schmidt Scientific Taiwan, Ltd.
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Taipei, Taiwan R.O.C.
TEL: 886-2-767-8890 or 746-2720
FAX: 886-2-767-8820

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2102/31 Ramkamhang Road
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FAX: 66-2-374-9965

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Pestas Prof. Elektr. Sist. Tic. V
Selcuklar Caddesi
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Haris Al Afaq Ltd.
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FAX: 971-4-281285

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Coasin Instromontos S.A.
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FAX: 598-2-492-659

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Calle 9 Con Calle 4, Edif. Edinurbi
Piso-3
La Urbina
Caracas 1070-A, Venezuela
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FAX: 58-2-241-1939

Vietnam
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Hanoi International Tech. Ctr
KM8, Highway 32, Cau Giay
Tu Liem, Hanoi
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TEL: 84-4-346186 or 346187
FAX: 84-4-346-188

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Western Scientific Co., Ltd.
Freeprot Mission Road
Freeport, Trinidad
West Indies
TEL: 809-673-0038
FAX: 809-673-0767

Yugoslavia
Jugoelektro Beograd
T & M Customer Support
Servicies
Knez Mihailova 33
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TEL: 38-11-182470
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Field Technical Sales
45, Kelvin Road North
P.O. Box Cy535 Causeway
Harare, Zimbabwe
TEL: 263-4-750381 or 750382
FAX: 263-4-729970

Chapter 7
Schematic Diagrams

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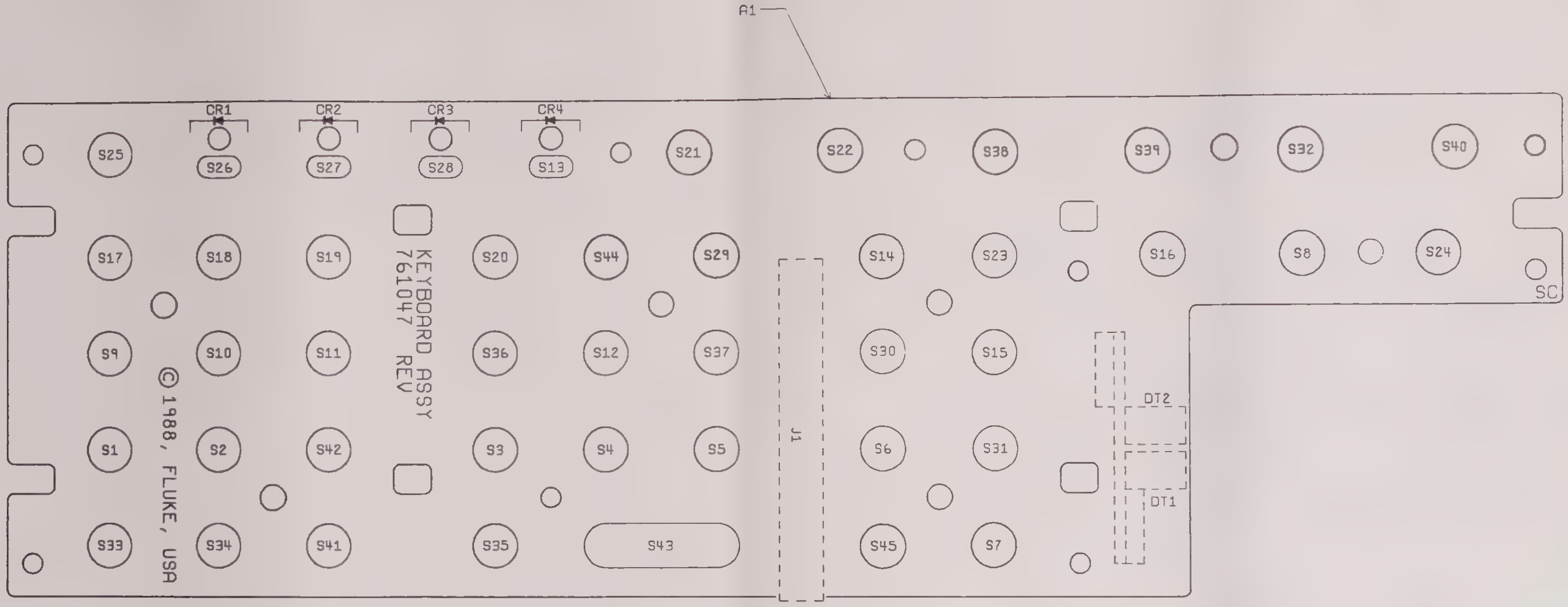

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Figure 7-1. A1 Keyboard PCA

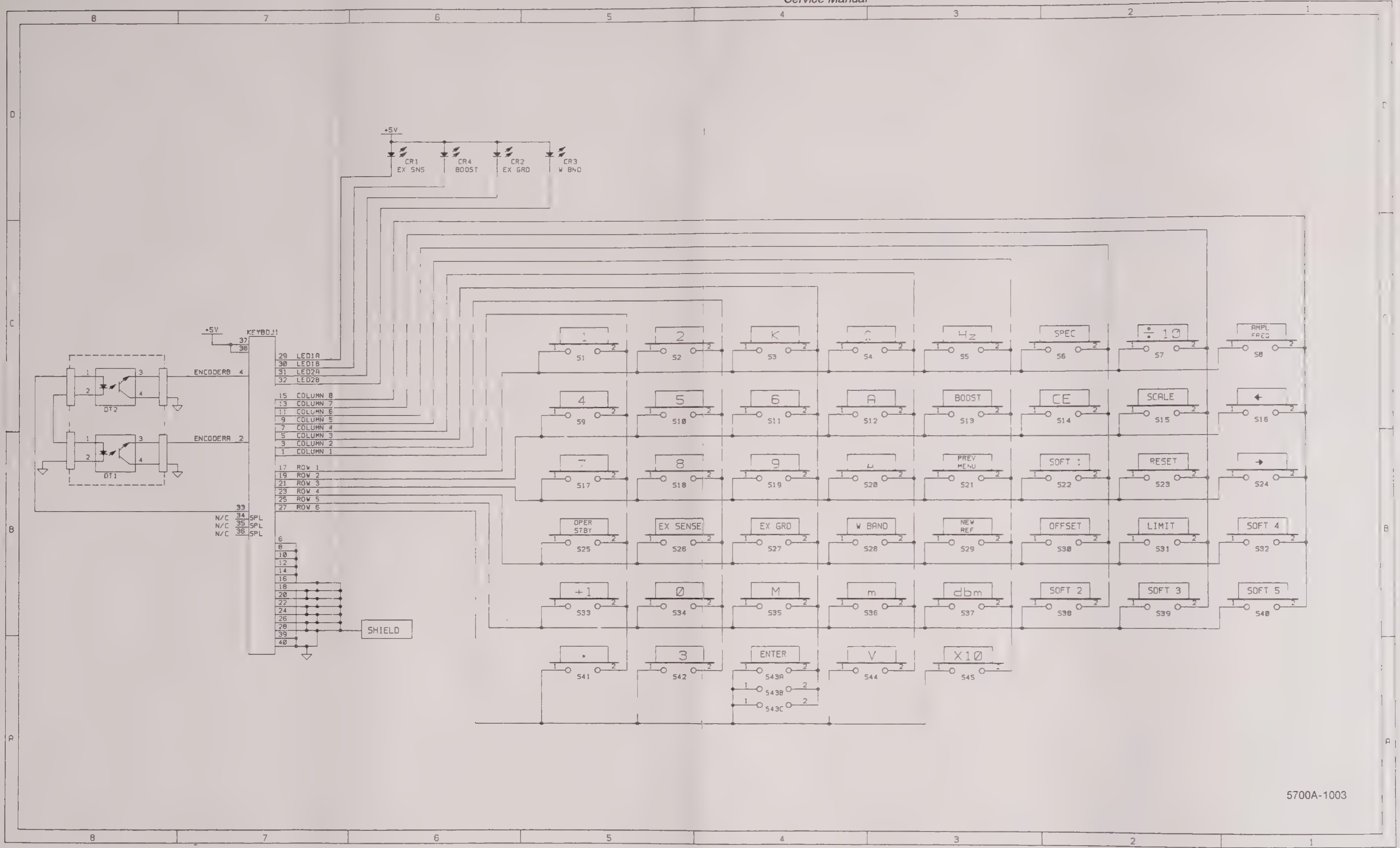
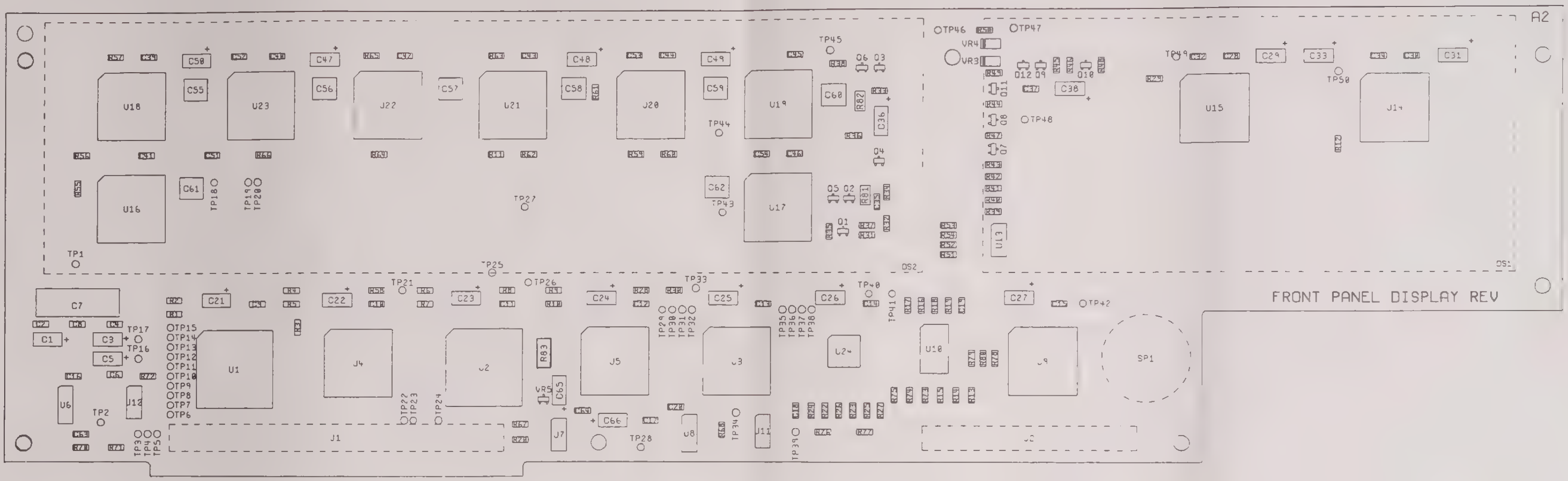


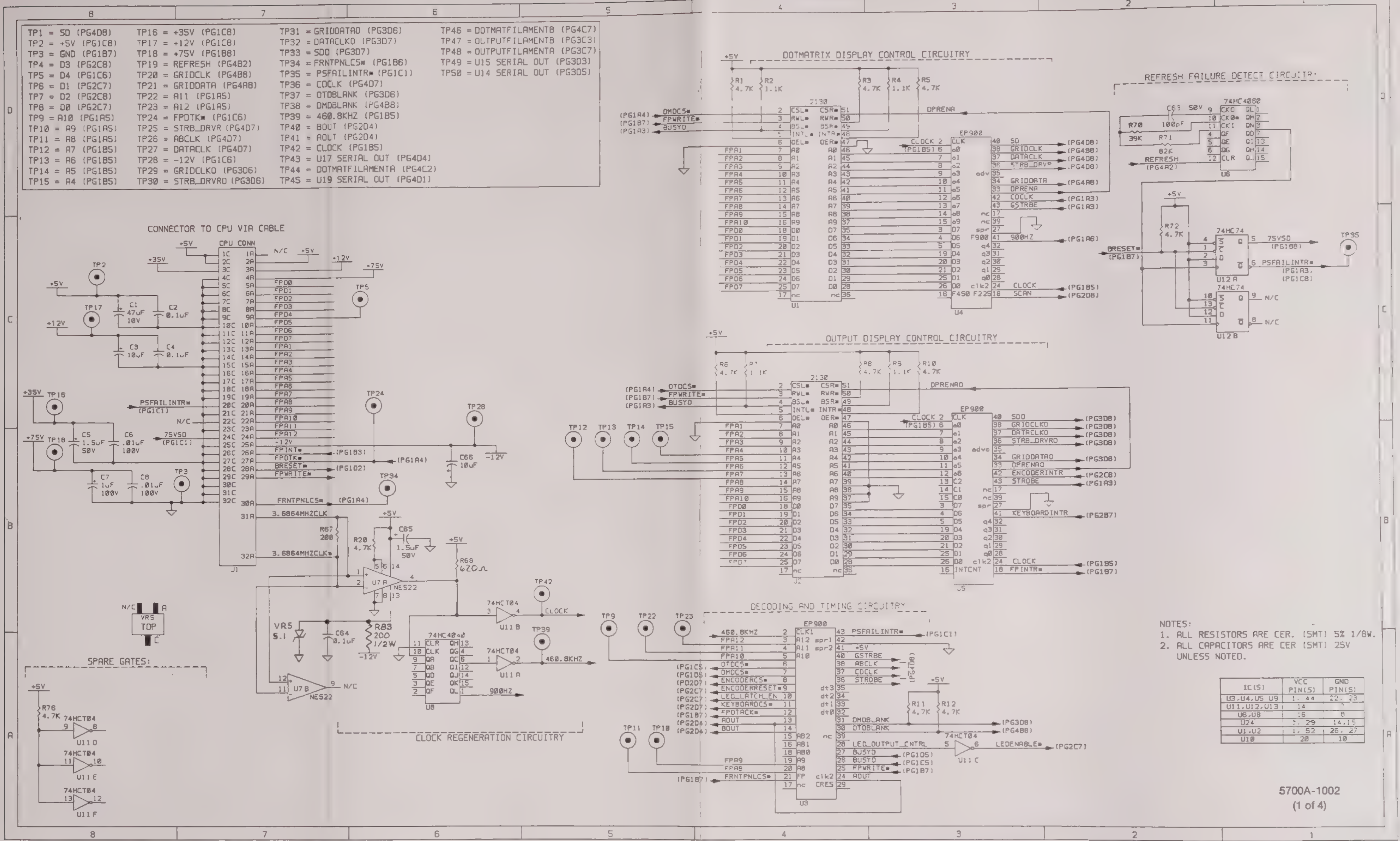
Figure 7-1. A1 Keyboard PCA (cont)



5700A-1602

Figure 7-2. A2 Front Panel PCA

TP1 = SD (PG4D8)
TP2 = +5V (PG1C8)
TP3 = GND (PG1B7)
TP4 = D3 (PG2C8)
TP5 = D4 (PG1C6)
TP6 = D1 (PG2C7)
TP7 = D2 (PG2C8)
TP8 = D0 (PG2C7)
TP9 = A10 (PG1A5)
TP10 = A9 (PG1A5)
TP11 = A8 (PG1A5)
TP12 = A7 (PG1B5)
TP13 = A6 (PG1B5)
TP14 = A5 (PG1B5)
TP15 = A4 (PG1B5)
TP16 = +35V (PG1C8)
TP17 = +12V (PG1C8)
TP18 = +75V (PG1B8)
TP19 = REFRESH (PG4B2)
TP20 = GRIDCLK (PG4B8)
TP21 = GRIDDATA (PG4A8)
TP22 = A11 (PG1A5)
TP23 = A12 (PG1A5)
TP24 = FPDTK* (PG1C6)
TP25 = STRB_DRVR (PG4D7)
TP26 = ABCLK (PG4D7)
TP27 = DATACLK (PG4D7)
TP28 = -12V (PG1C6)
TP29 = GRIDCLKO (PG3D6)
TP30 = STRB_DRVRO (PG3D6)
TP31 = GRIDDATAO (PG3D6)
TP32 = DATACLKO (PG3D7)
TP33 = SDO (PG3D7)
TP34 = FRNTPNLCS* (PG1B6)
TP35 = PSFAILINTR* (PG1C1)
TP36 = CDCLK (PG4D7)
TP37 = OTOBLANK (PG3D6)
TP38 = DMDBLANK (PG4B8)
TP39 = 460.8KHZ (PG1B5)
TP40 = BOUT (PG2D4)
TP41 = AOLT (PG2D4)
TP42 = CLOCK (PG1B5)
TP43 = U17 SERIAL OUT (PG4D4)
TP44 = DOTMATFILAMENTA (PG4C2)
TP45 = U19 SERIAL OUT (PG4D1)
TP46 = DOTMATFILAMENTB (PG4C7)
TP47 = OUTPUTFILAMENTB (PG3C3)
TP48 = OUTPUTFILAMENTA (PG3C7)
TP49 = U15 SERIAL OUT (PG3D3)
TP50 = U14 SERIAL OUT (PG3D5)



NOTES:
1. ALL RESISTORS ARE CER. (SMT) 5% 1/8W.
2. ALL CAPACITORS ARE CER (SMT) 25V
UNLESS NOTED.

IC(S)	VCC PIN(S)	GND PIN(S)
U3,U4,U5 U9	1, 44	22, 23
U11,U12,U13	14	7
U6,U8	16	8
U24	1, 29	14,15
U1,U2	1, 52	26, 27
U10	20	10

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Figure 7-2. A2 Front Panel PCA (cont)

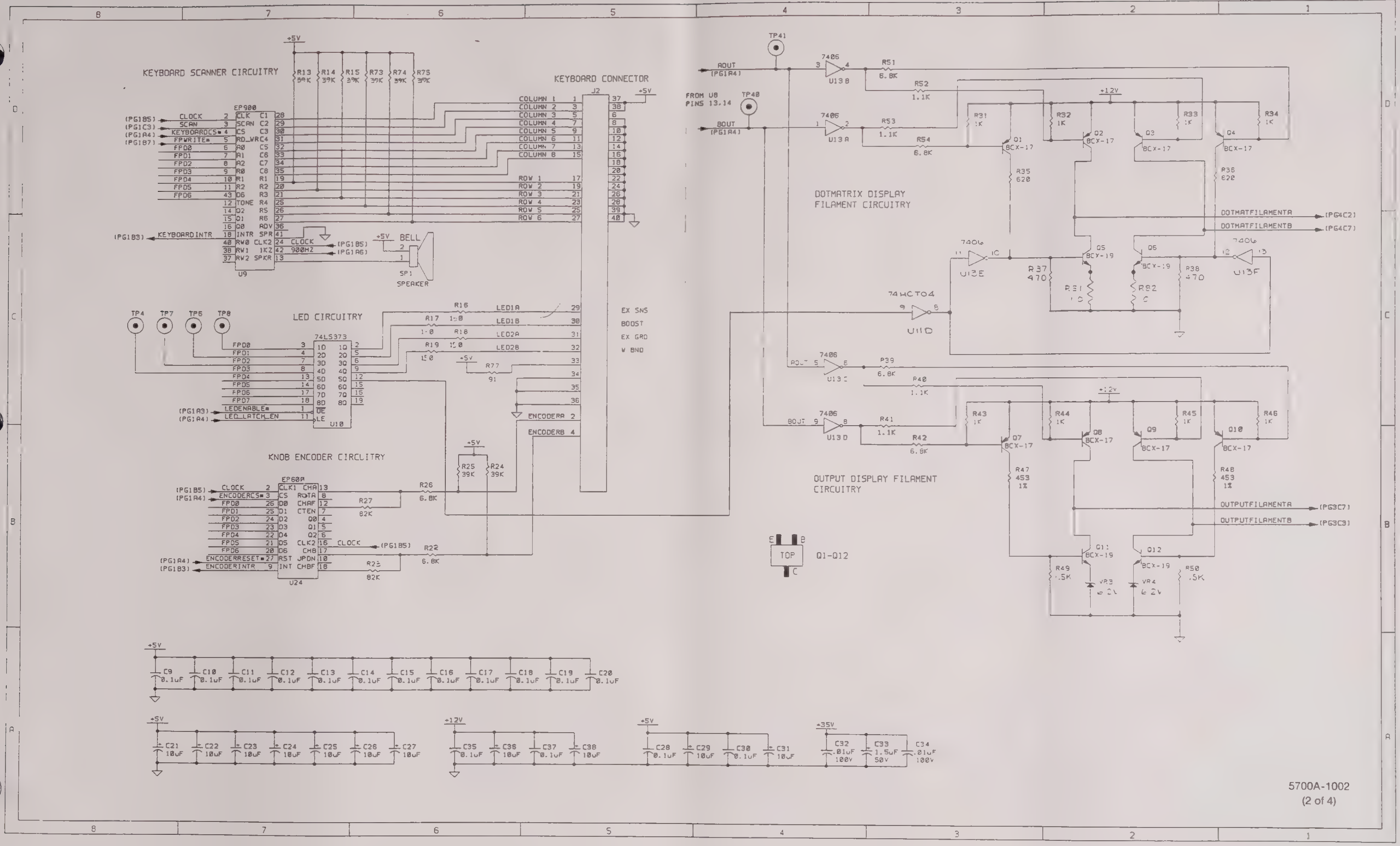
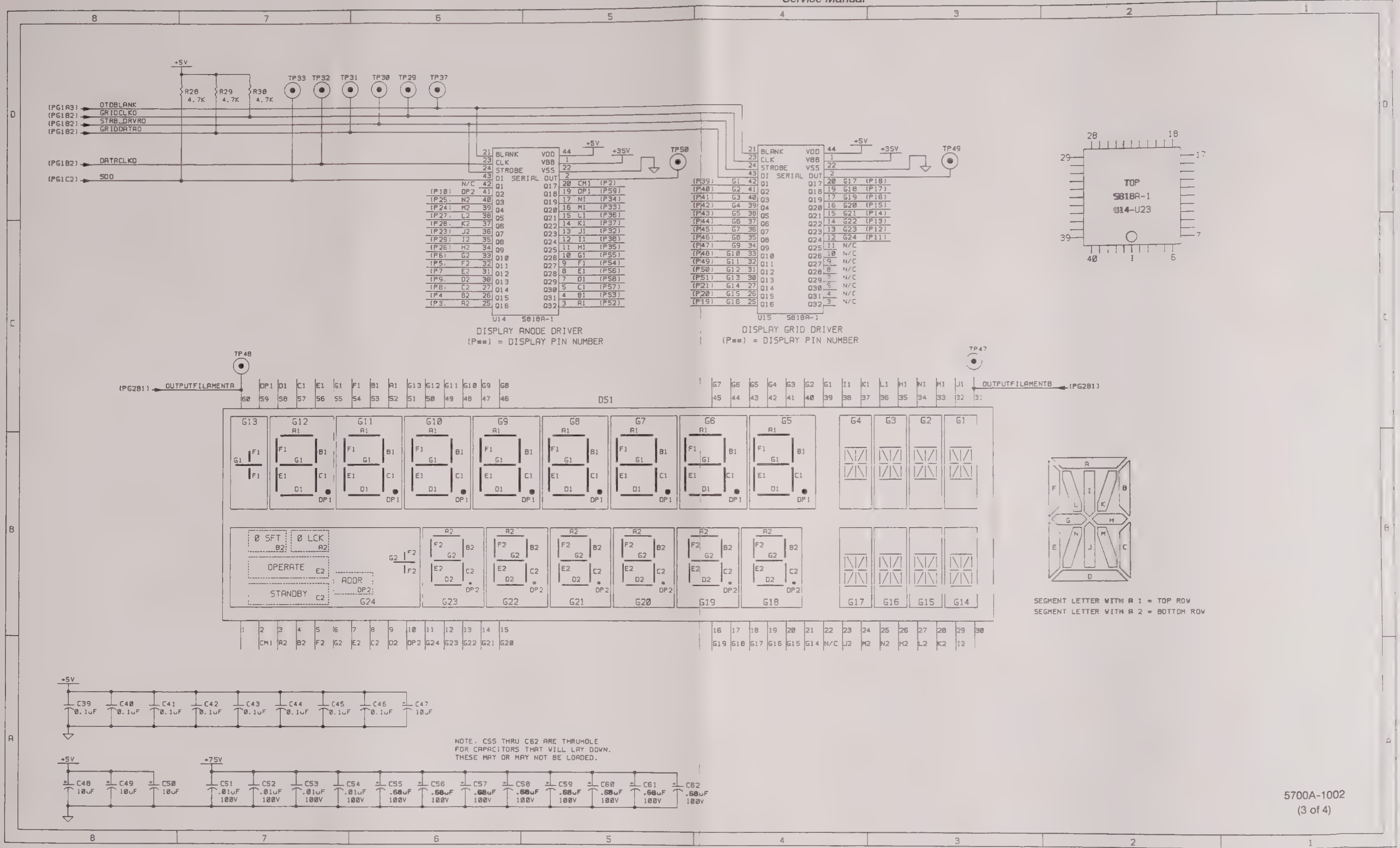


Figure 7-2. A2 Front Panel PCA (cont)



NOTE. C55 THRU C62 ARE THRUHOLE FOR CAPACITORS THAT WILL LAY DOWN. THESE MAY OR MAY NOT BE LOADED.

SEGMENT LETTER WITH A 1 = TOP ROW
SEGMENT LETTER WITH A 2 = BOTTOM ROW

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Figure 7-2. A2 Front Panel PCA (cont)

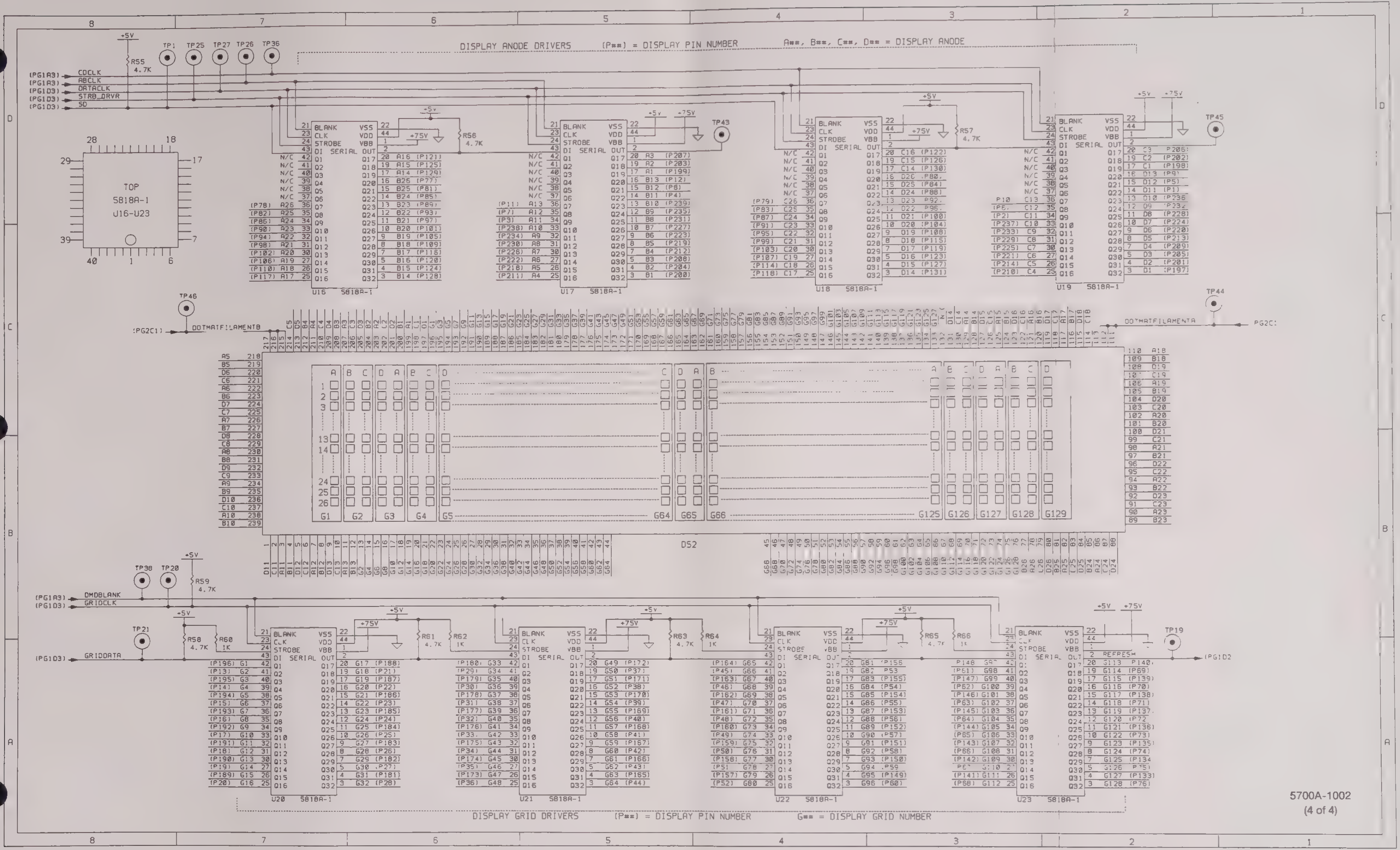
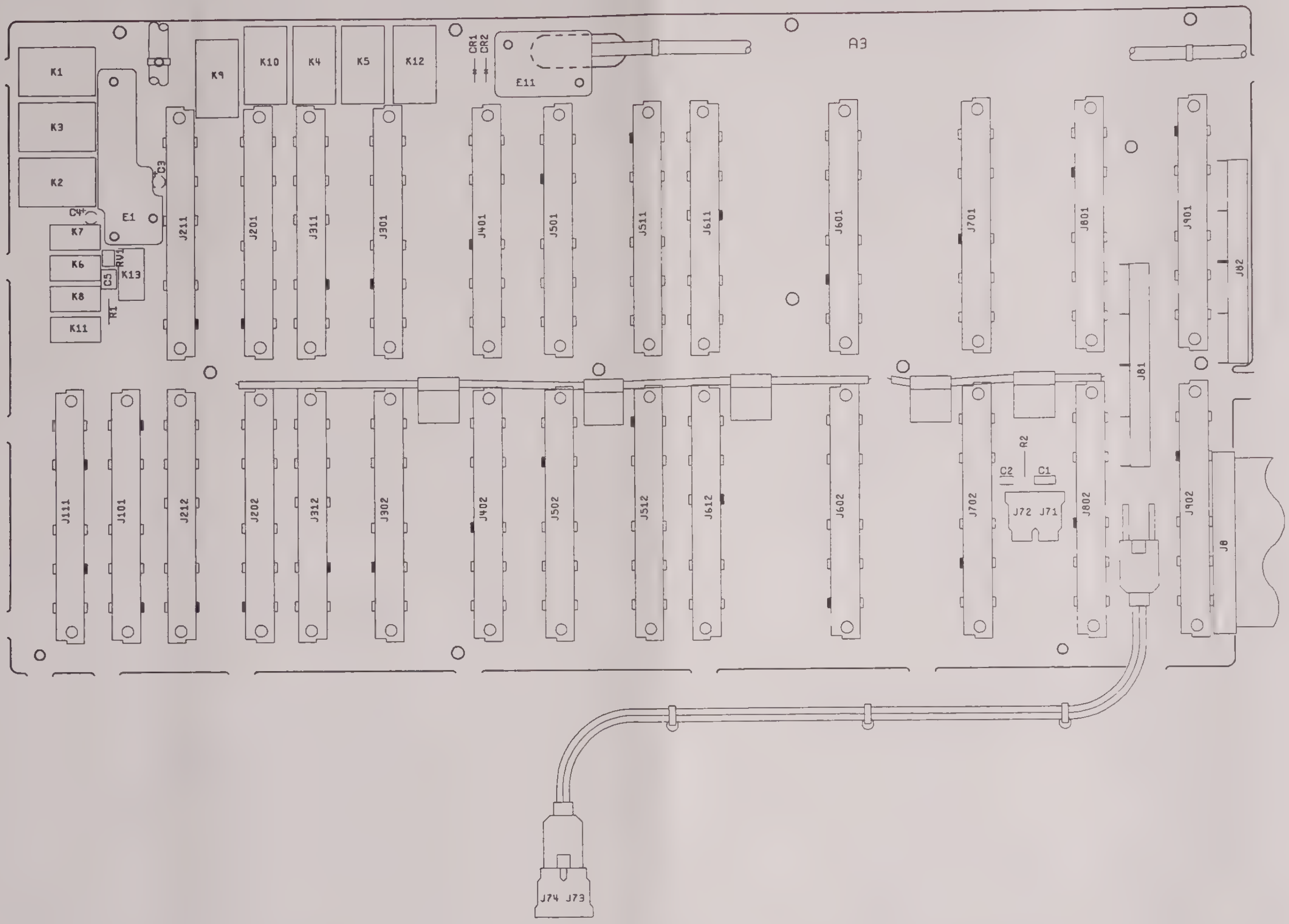
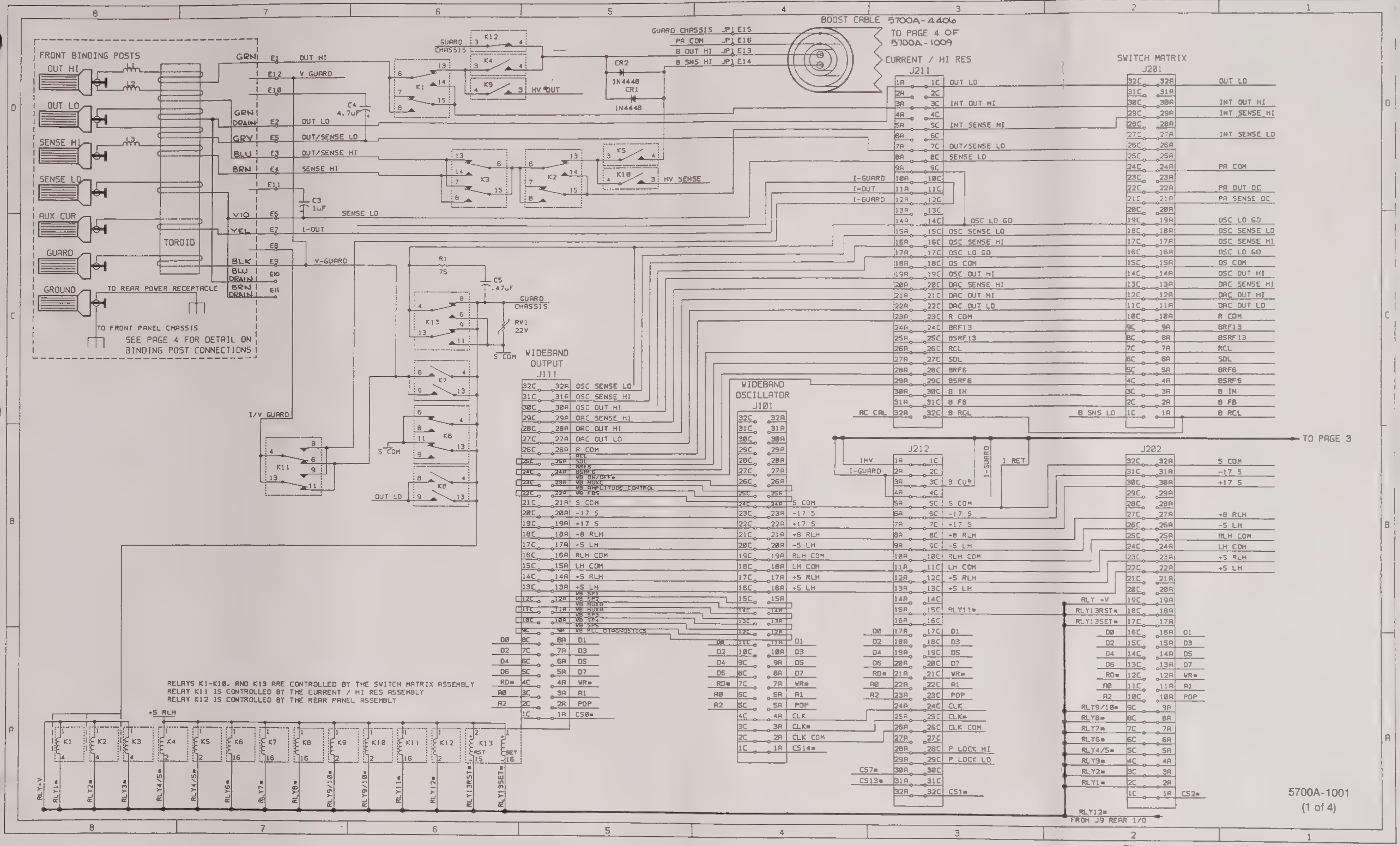


Figure 7-2. A2 Front Panel PCA (cont)



5700A-1601

Figure 7-3. A3 Analog Motherboard PCA



RELAYS K1-K10, AND K13 ARE CONTROLLED BY THE SWITCH MATRIX ASSEMBLY
RELAY K11 IS CONTROLLED BY THE CURRENT / HI RES ASSEMBLY
RELAY K12 IS CONTROLLED BY THE REAR PANEL ASSEMBLY

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Figure 7-3. A3 Analog Motherboard PCA (cont)

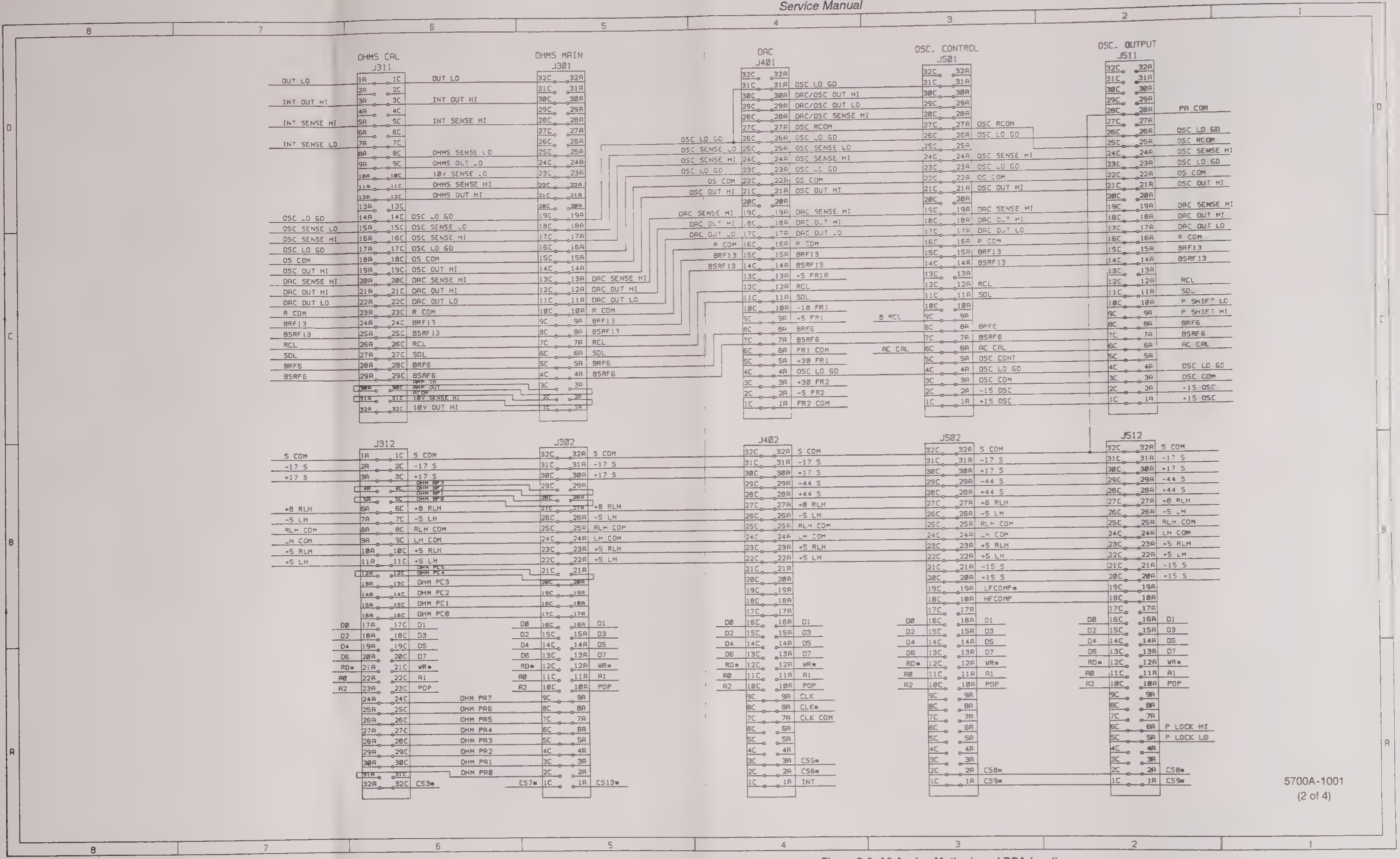


Figure 7-3. A3 Analog Motherboard PCA (cont)

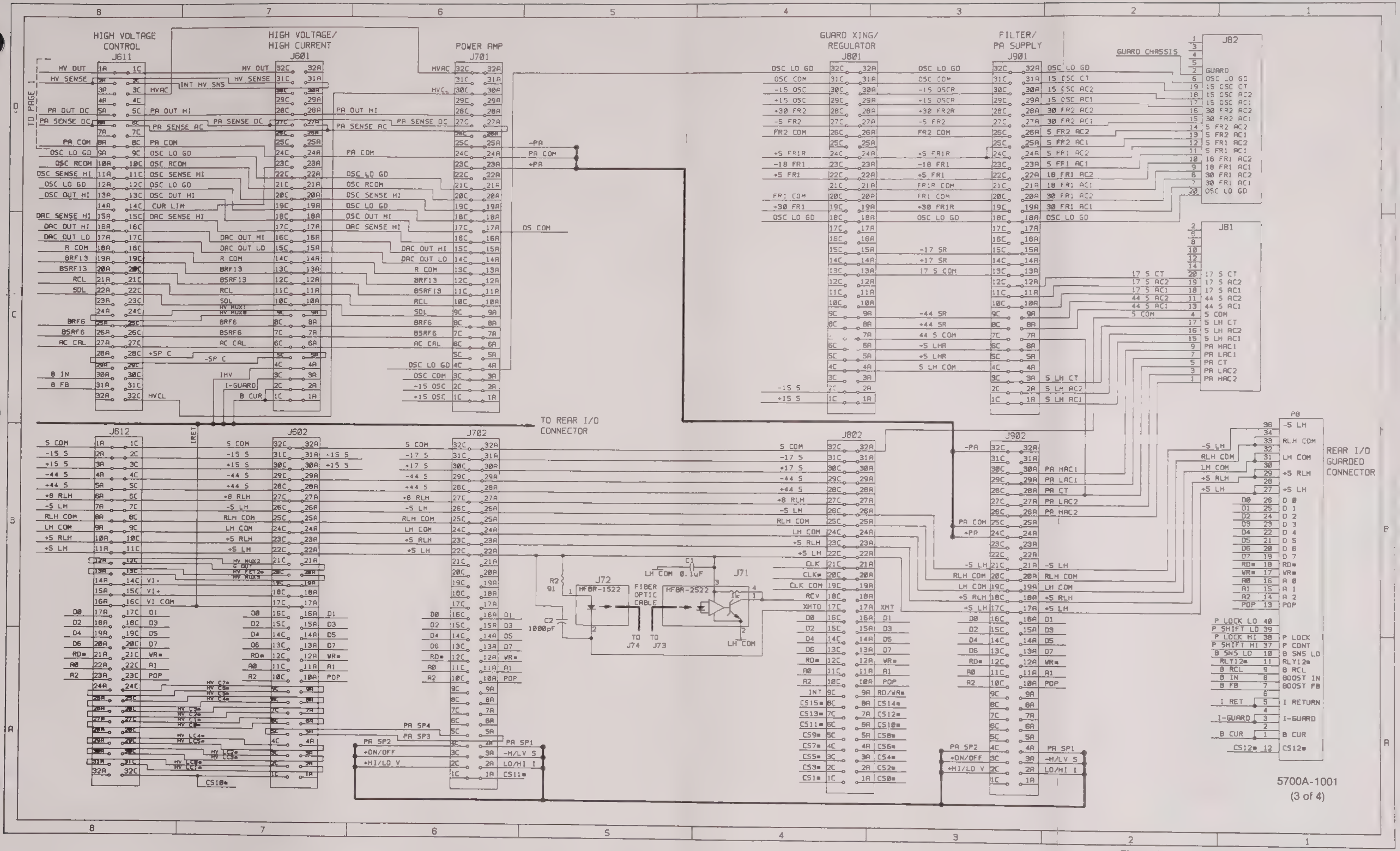


Figure 7-3. A3 Analog Motherboard PCA (cont)

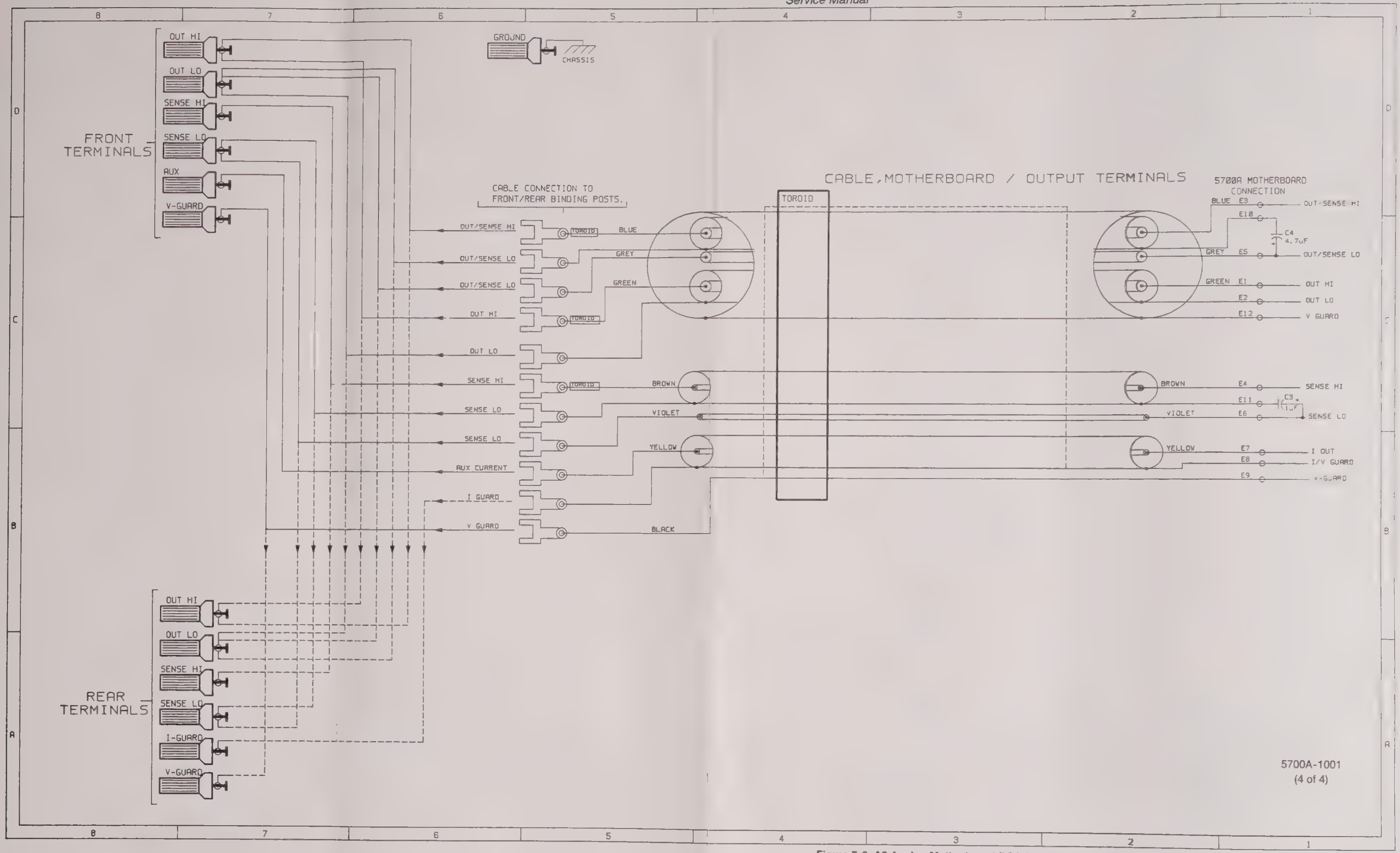


Figure 7-3. A3 Analog Motherboard PCA (cont)

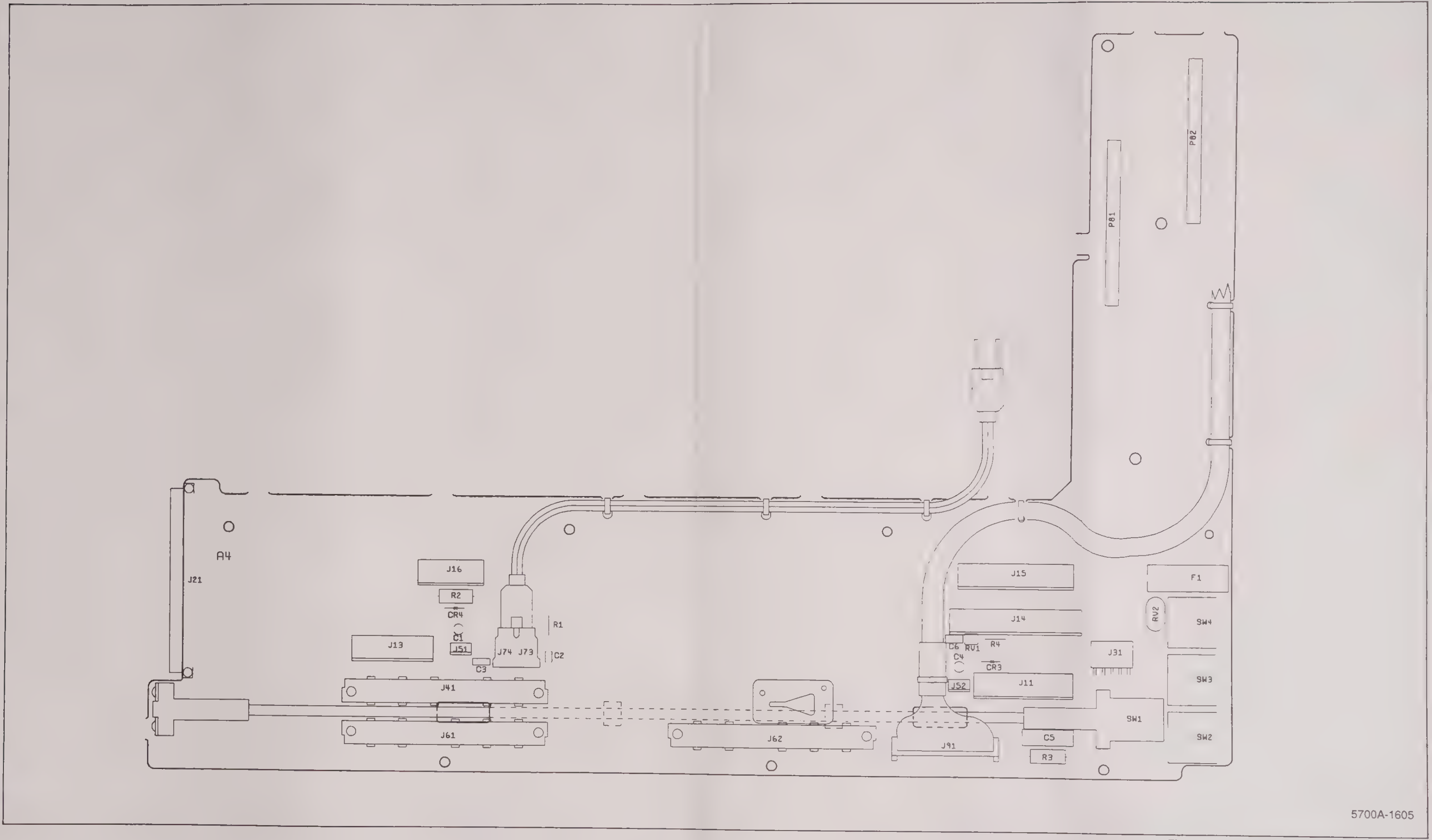
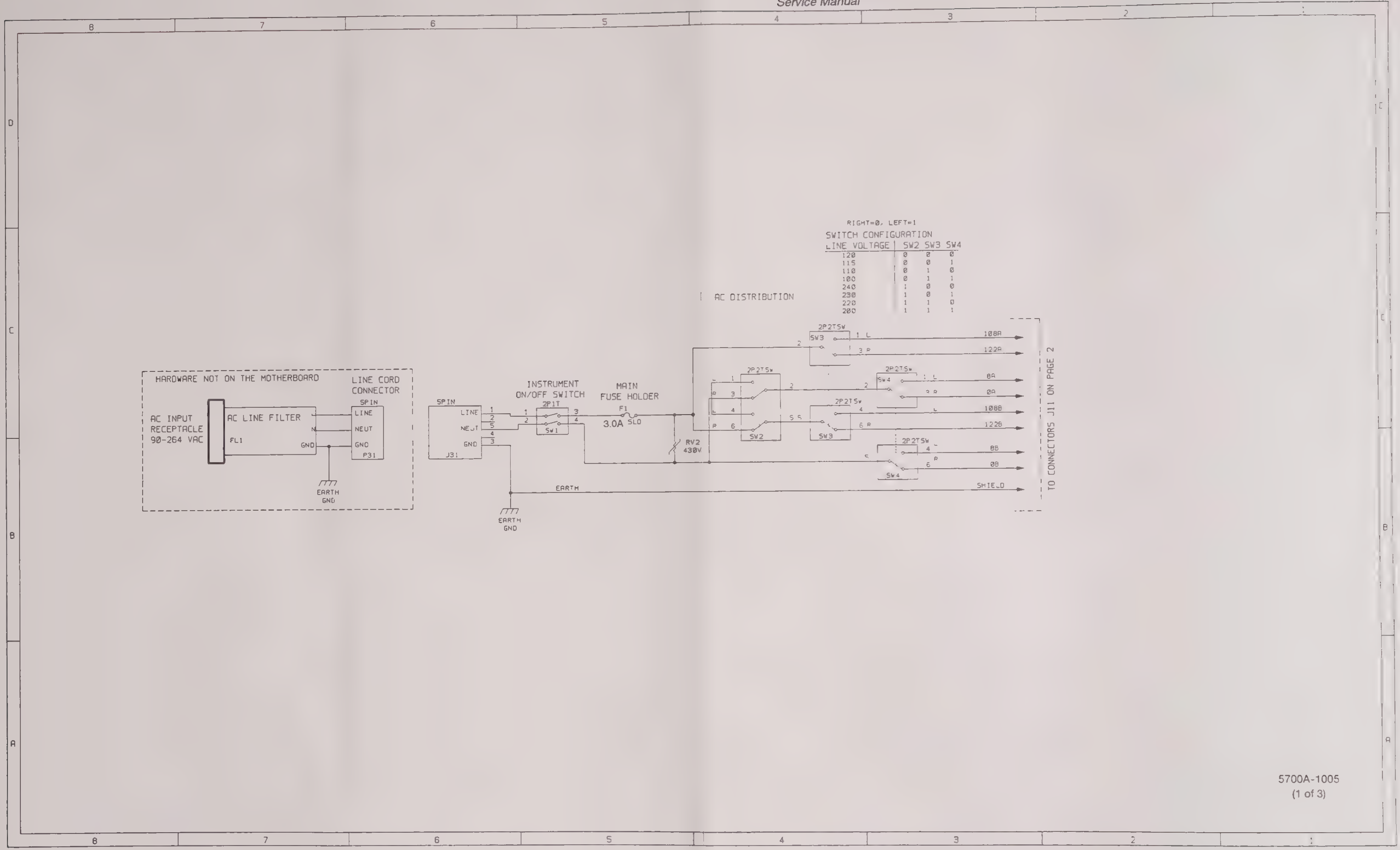


Figure 7-4. A4 Digital Motherboard PCA



RIGHT=0, LEFT=1

SWITCH CONFIGURATION

LINE VOLTAGE	SW2	SW3	SW4
120	0	0	0
115	0	0	1
110	0	1	0
100	0	1	1
240	1	0	0
230	1	0	1
220	1	1	0
200	1	1	1

Figure 7-4. A4 Digital Motherboard PCA (cont)

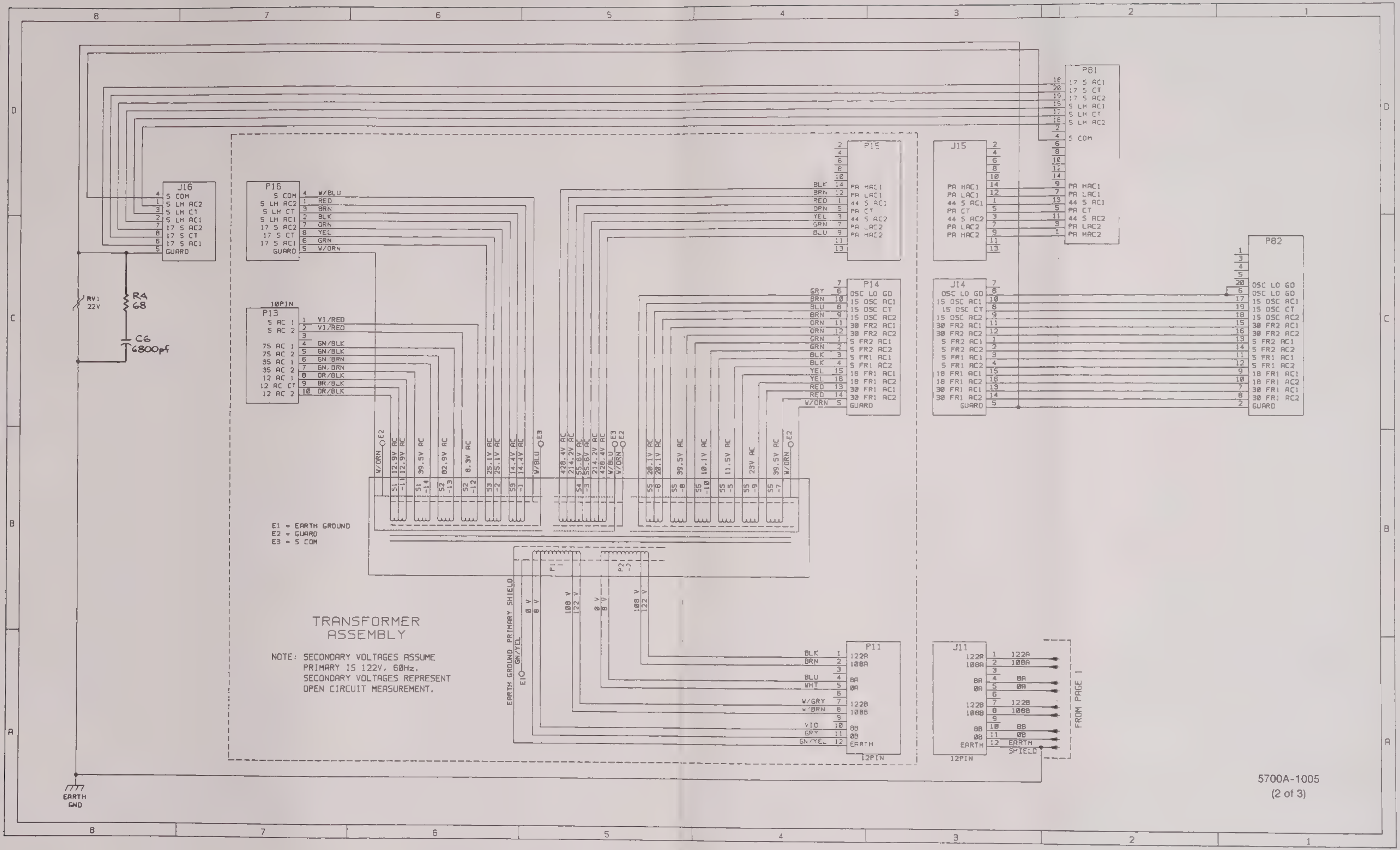


Figure 7-4. A4 Digital Motherboard PCA (cont)

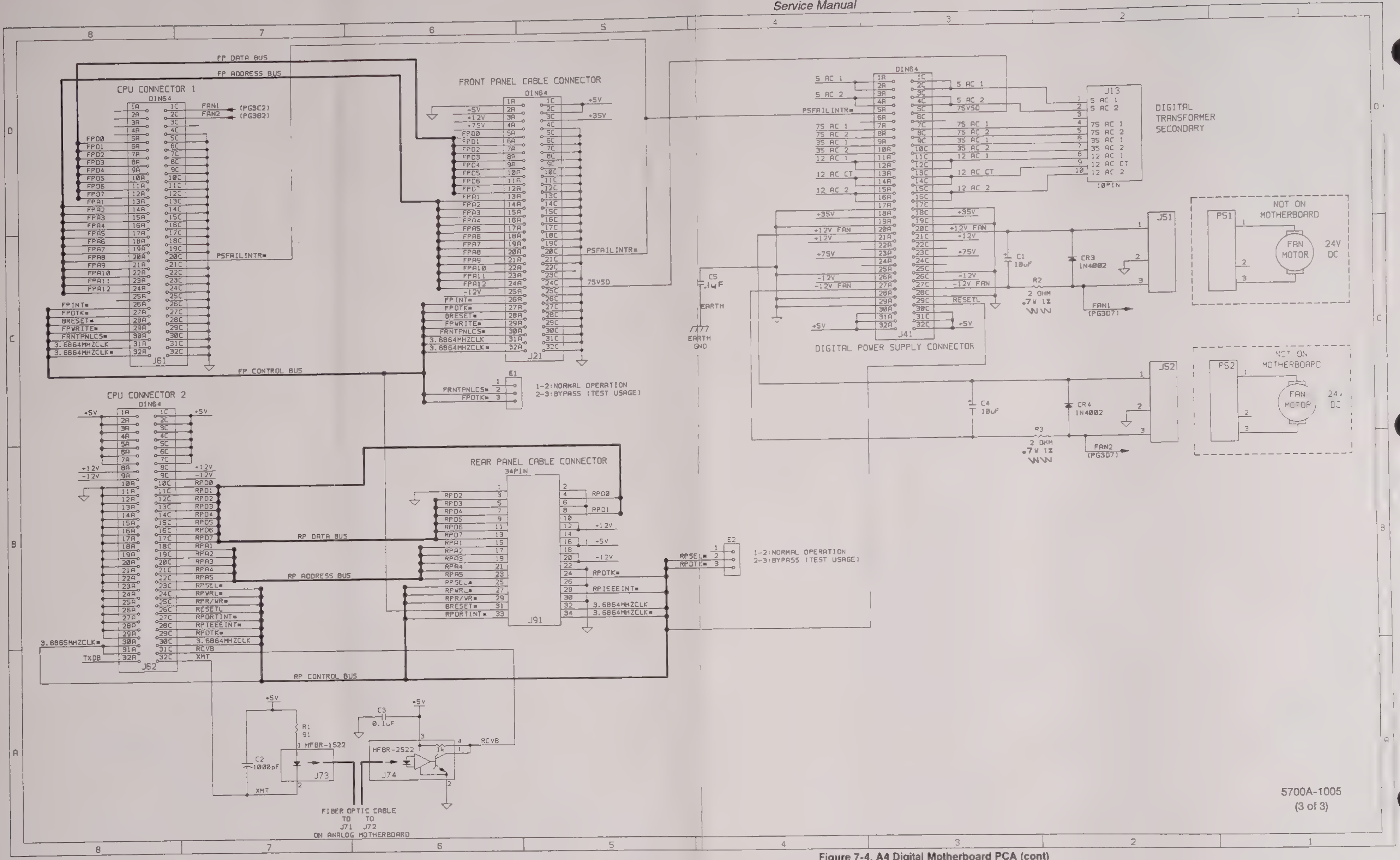


Figure 7-4. A4 Digital Motherboard PCA (cont)

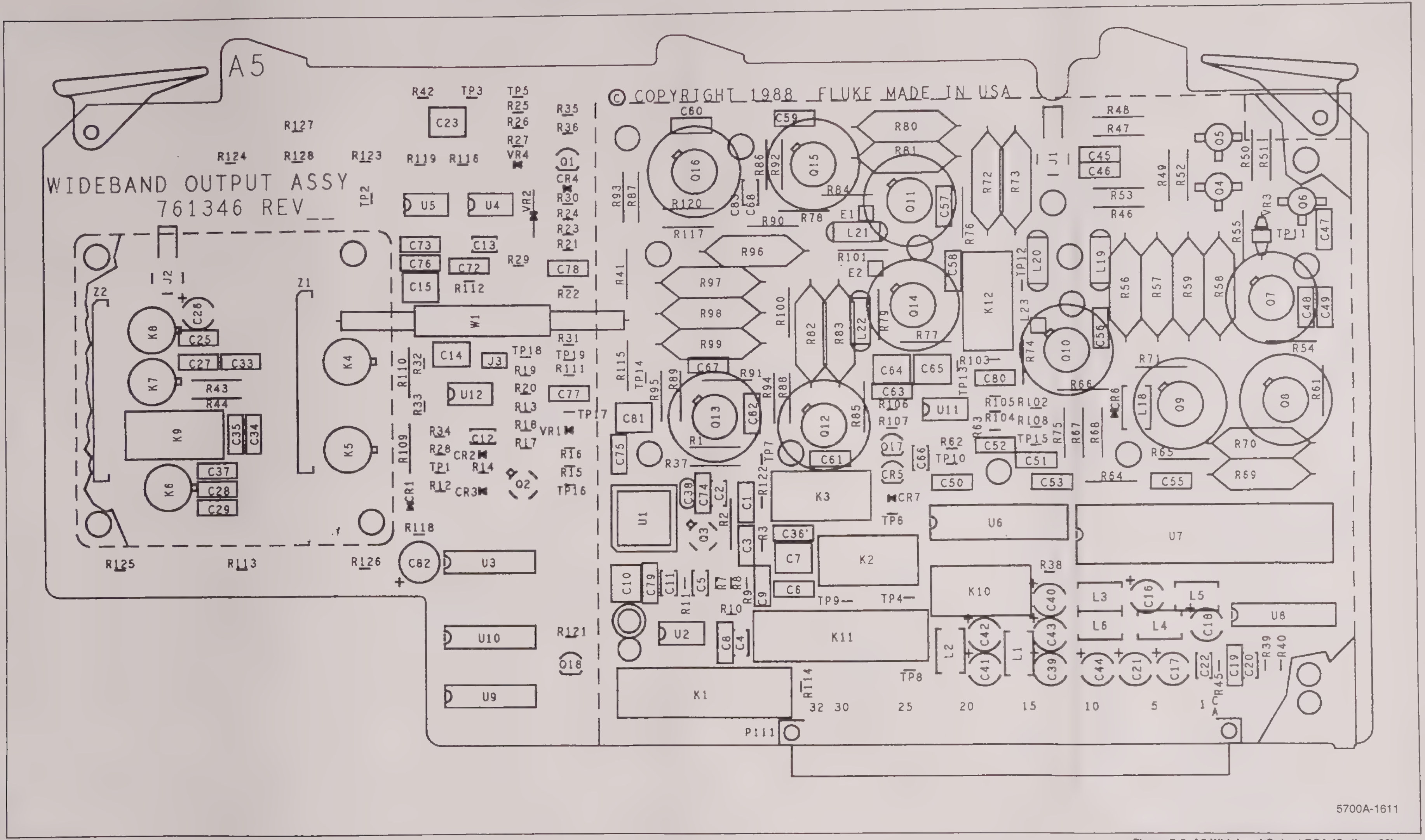
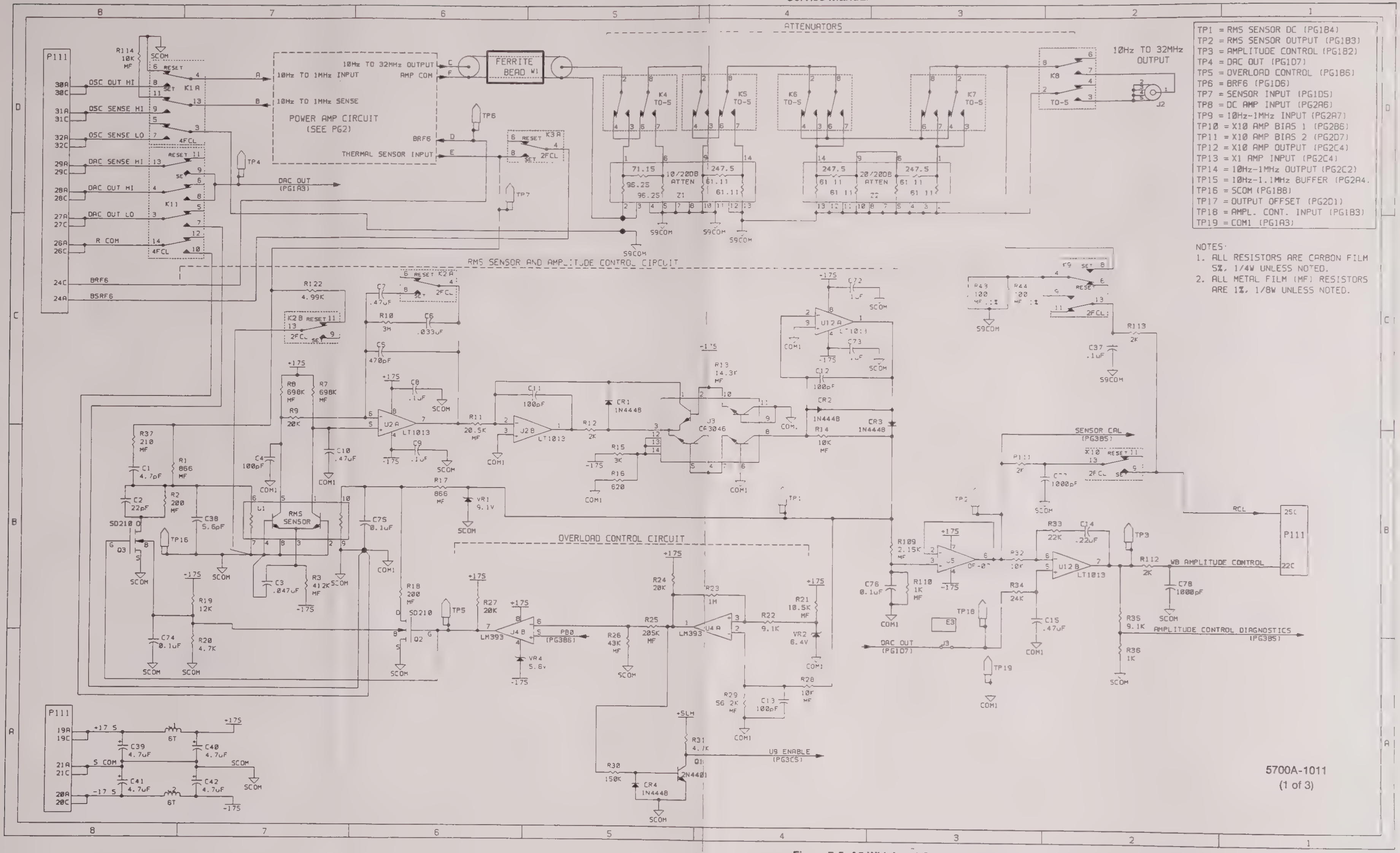


Figure 7-5. A5 Wideband Output PCA (Option -03)



TP1 = RMS SENSOR DC (PG1B4)
TP2 = RMS SENSOR OUTPUT (PG1B3)
TP3 = AMPLITUDE CONTROL (PG1B2)
TP4 = DAC OUT (PG1D7)
TP5 = OVERLOAD CONTROL (PG1B6)
TP6 = BRF6 (PG1D6)
TP7 = SENSOR INPUT (PG1D5)
TP8 = DC AMP INPUT (PG2A6)
TP9 = 10Hz-1MHz INPUT (PG2A7)
TP10 = X10 AMP BIAS 1 (PG2B6)
TP11 = X10 AMP BIAS 2 (PG2D7)
TP12 = X10 AMP OUTPUT (PG2C4)
TP13 = X1 AMP INPUT (PG2C4)
TP14 = 10Hz-1MHz OUTPUT (PG2C2)
TP15 = 10Hz-1.1MHz BUFFER (PG2A4.
TP16 = SCOM (PG1B8)
TP17 = OUTPUT OFFSET (PG2D1)
TP18 = AMPL. CONT. INPUT (PG1B3)
TP19 = COM1 (PG1A3)

NOTES:
1. ALL RESISTORS ARE CARBON FILM 5%, 1/4W UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.

Figure 7-5. A5 Wideband Output PCA (Option -03) (cont)

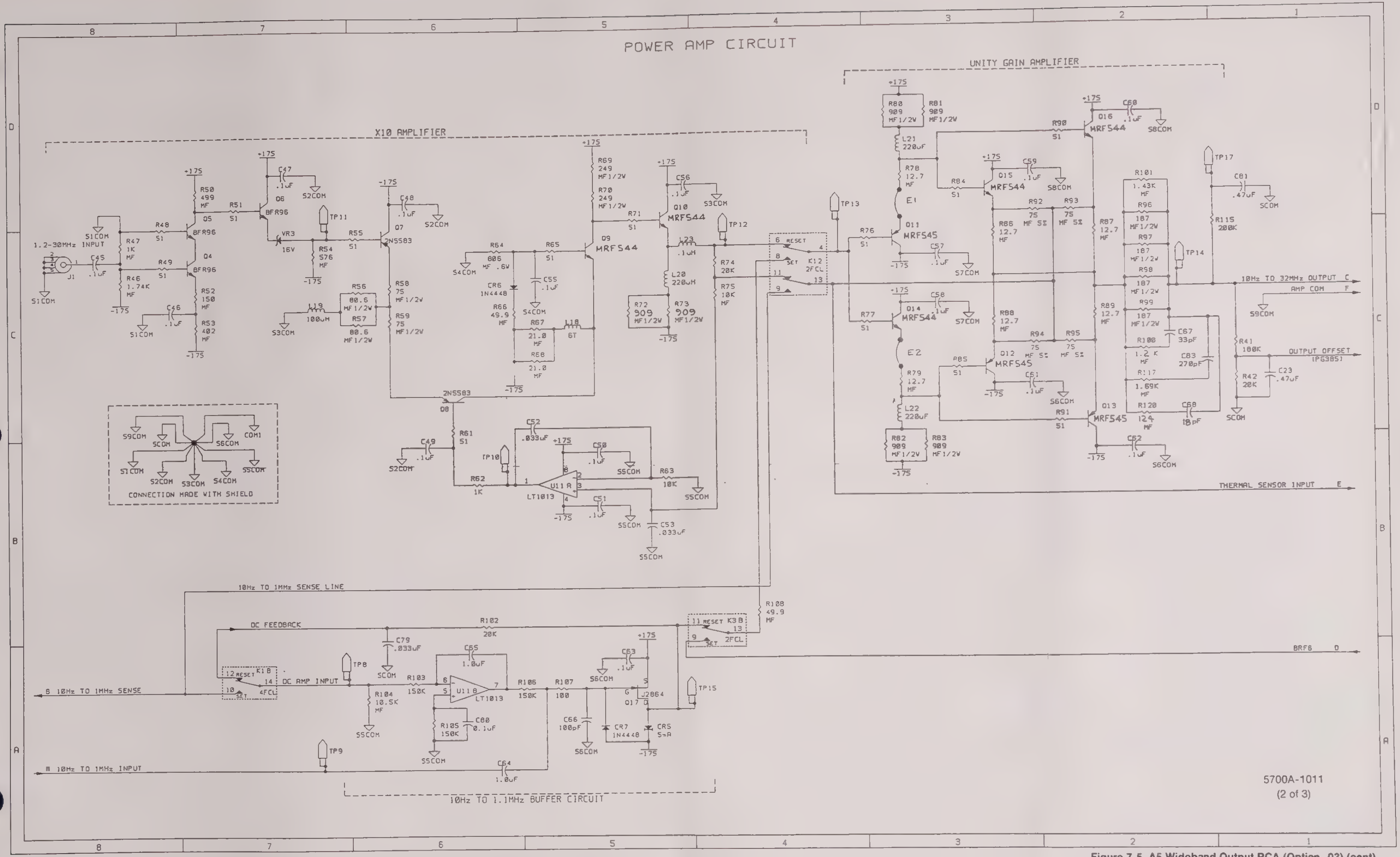
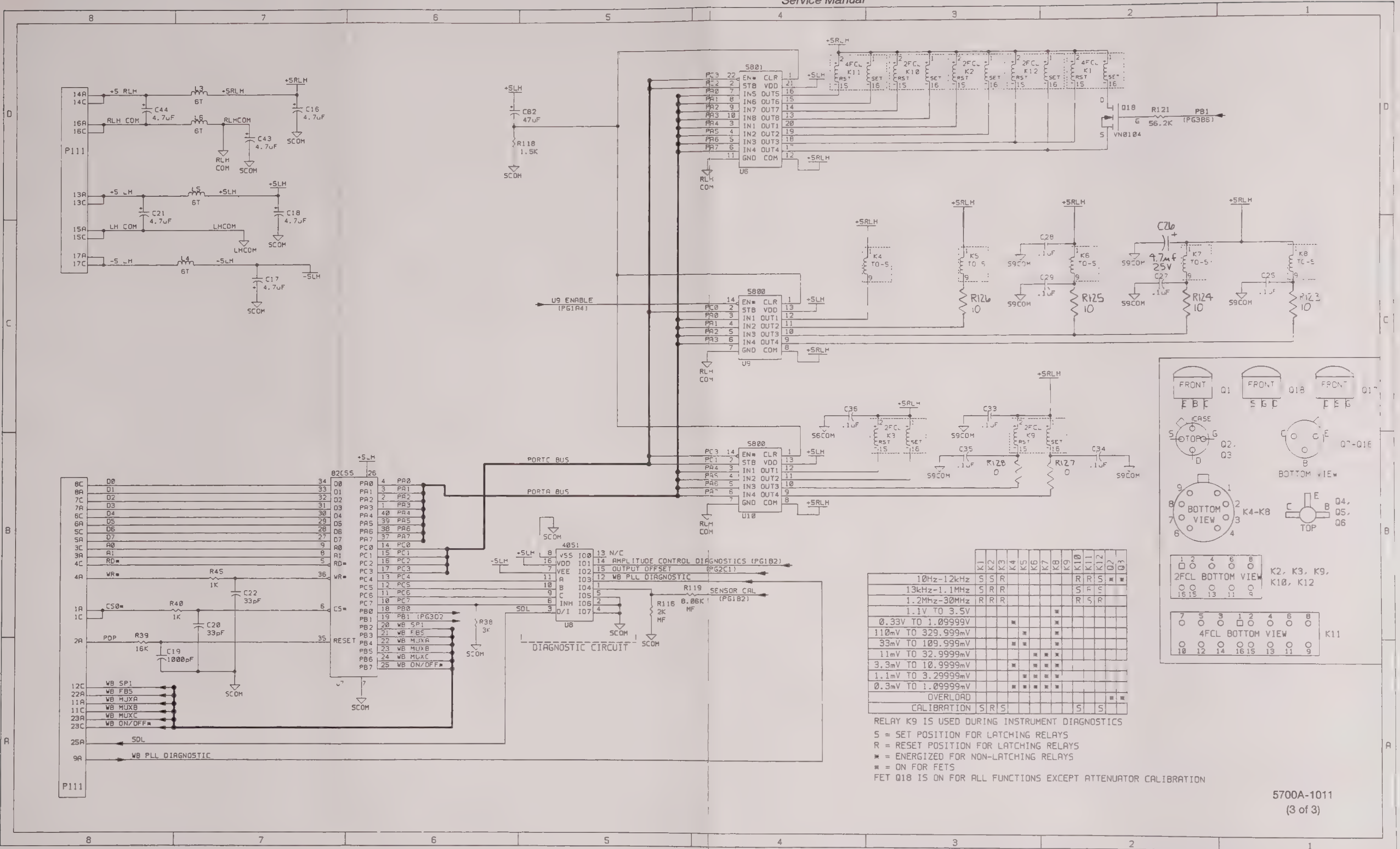


Figure 7-5. A5 Wideband Output PCA (Option -03) (cont)



	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	Q2	Q3
10Hz-12kHz	S	S	R							R	R	S	■	✱
13kHz-1.1MHz	S	R	R							S	R	S		
1.2MHz-30MHz	R	R	R							R	S	R		
1.1V TO 3.5V								✱						
0.33V TO 1.09999V				✱				✱						
110mV TO 329.999mV					✱			✱						
33mV TO 109.999mV				✱	✱			✱						
11mV TO 32.9999mV						✱	✱	✱						
3.3mV TO 10.9999mV				✱		✱	✱	✱						
1.1mV TO 3.29999mV					✱	✱	✱	✱						
0.3mV TO 1.09999mV				✱	✱	✱	✱	✱						
OVERLOAD													■	✱
CALIBRATION	S	R	S							S		S		

RELAY K9 IS USED DURING INSTRUMENT DIAGNOSTICS

S = SET POSITION FOR LATCHING RELAYS
R = RESET POSITION FOR LATCHING RELAYS
✱ = ENERGIZED FOR NON-LATCHING RELAYS
■ = ON FOR FETS
FET Q18 IS ON FOR ALL FUNCTIONS EXCEPT ATTENUATOR CALIBRATION

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(3 of 3)

Figure 7-5. A5 Wideband Output PCA (Option -03) (cont)

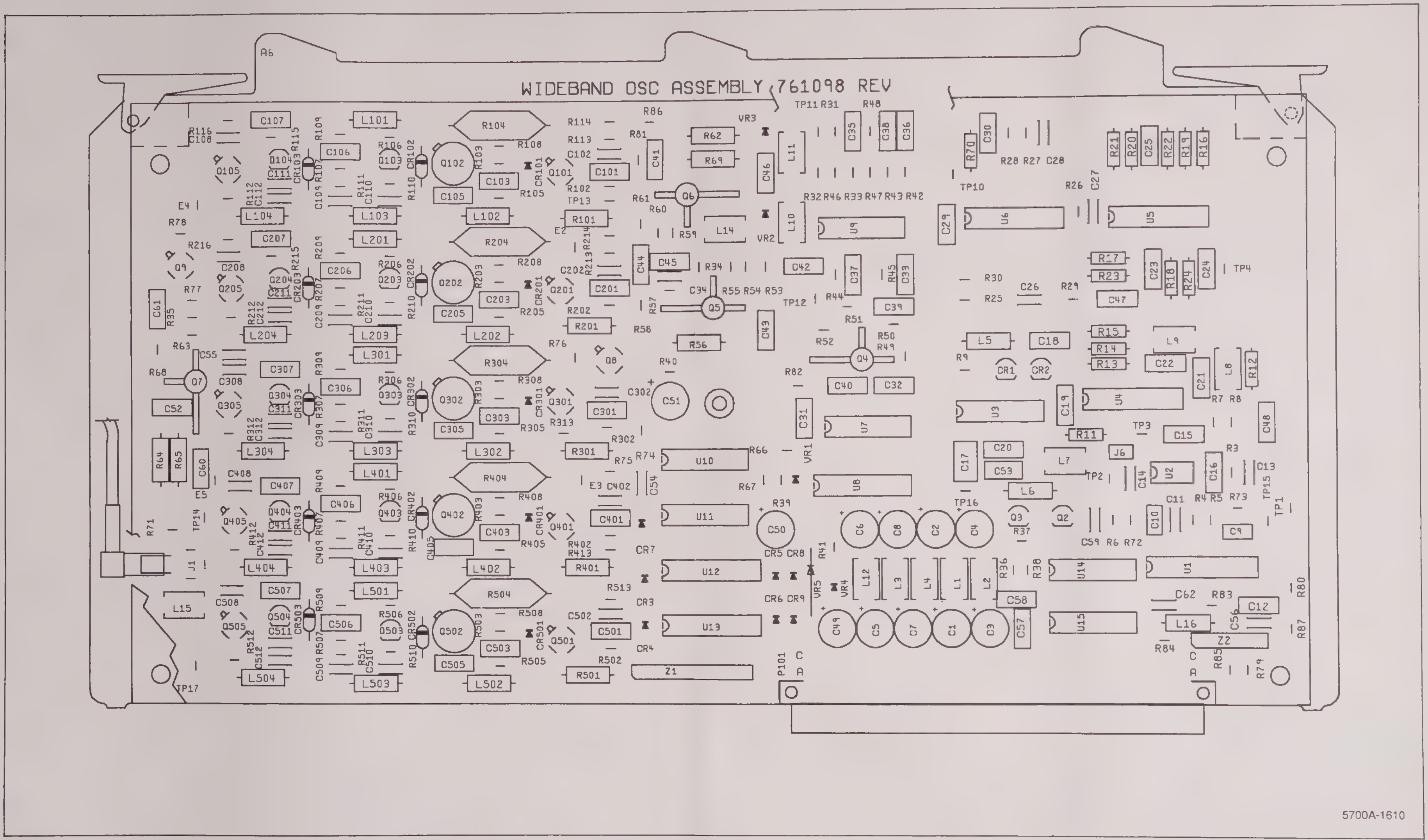
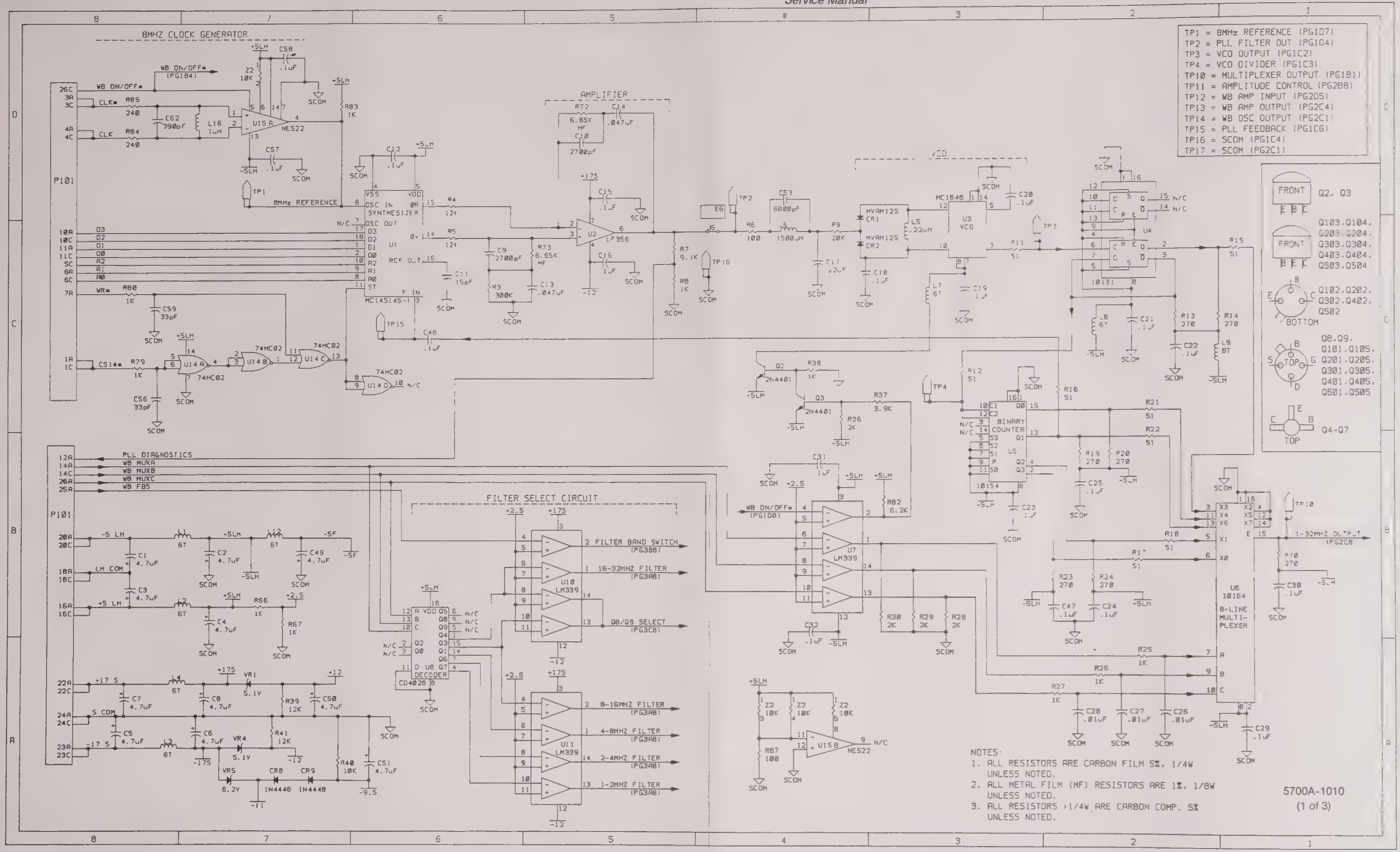


Figure 7-6. A6 Wideband Oscillator PCA (Option -03)



NOTES:
1. ALL RESISTORS ARE CARBON FILM 5%, 1/4W UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.
3. ALL RESISTORS >1/4W ARE CARBON COMP. 5% UNLESS NOTED.

Figure 7-6. A6 Wideband Oscillator PCA (Option -03)

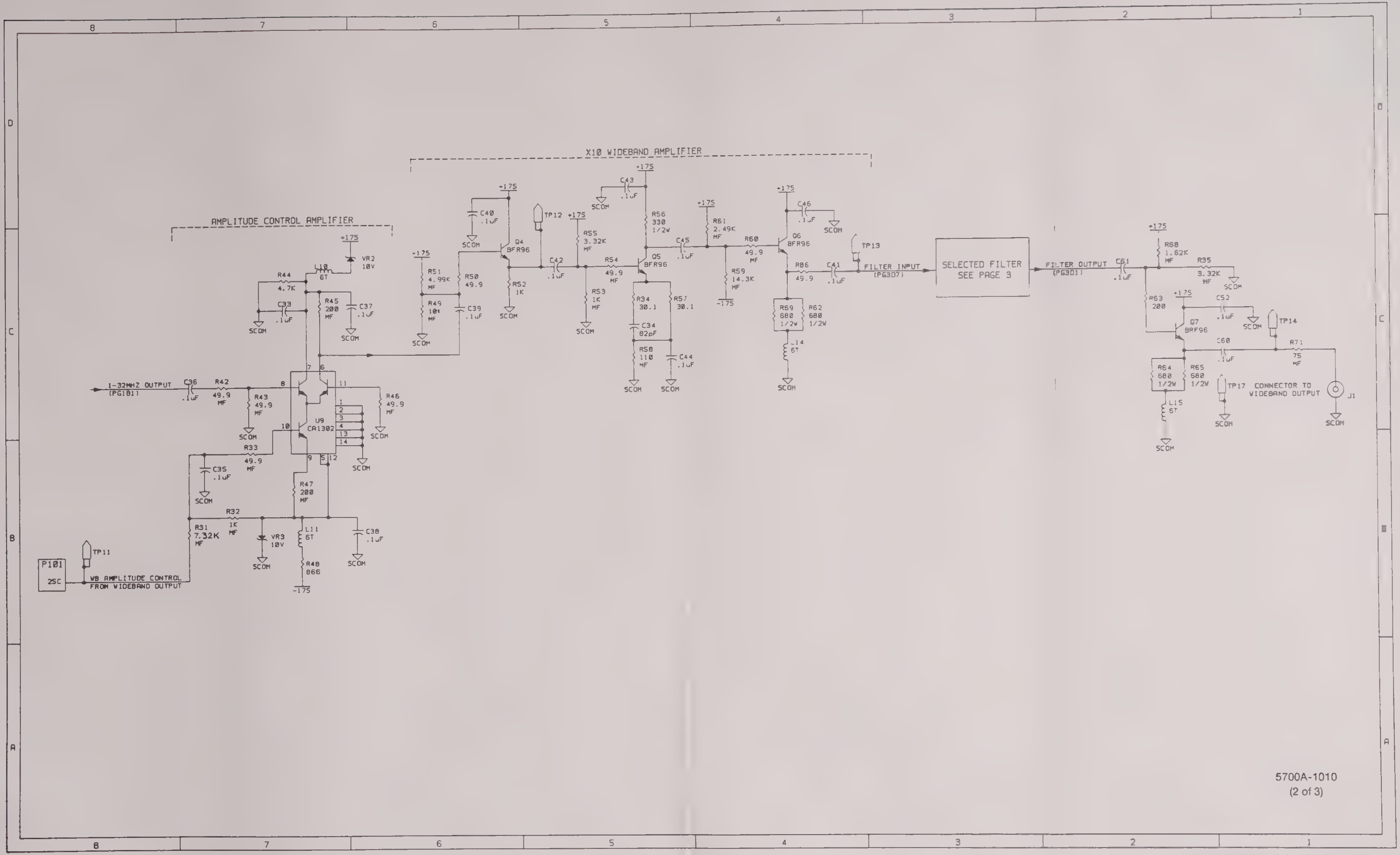


Figure 7-6. A6 Wideband Oscillator PCA (Option -03) (cont)

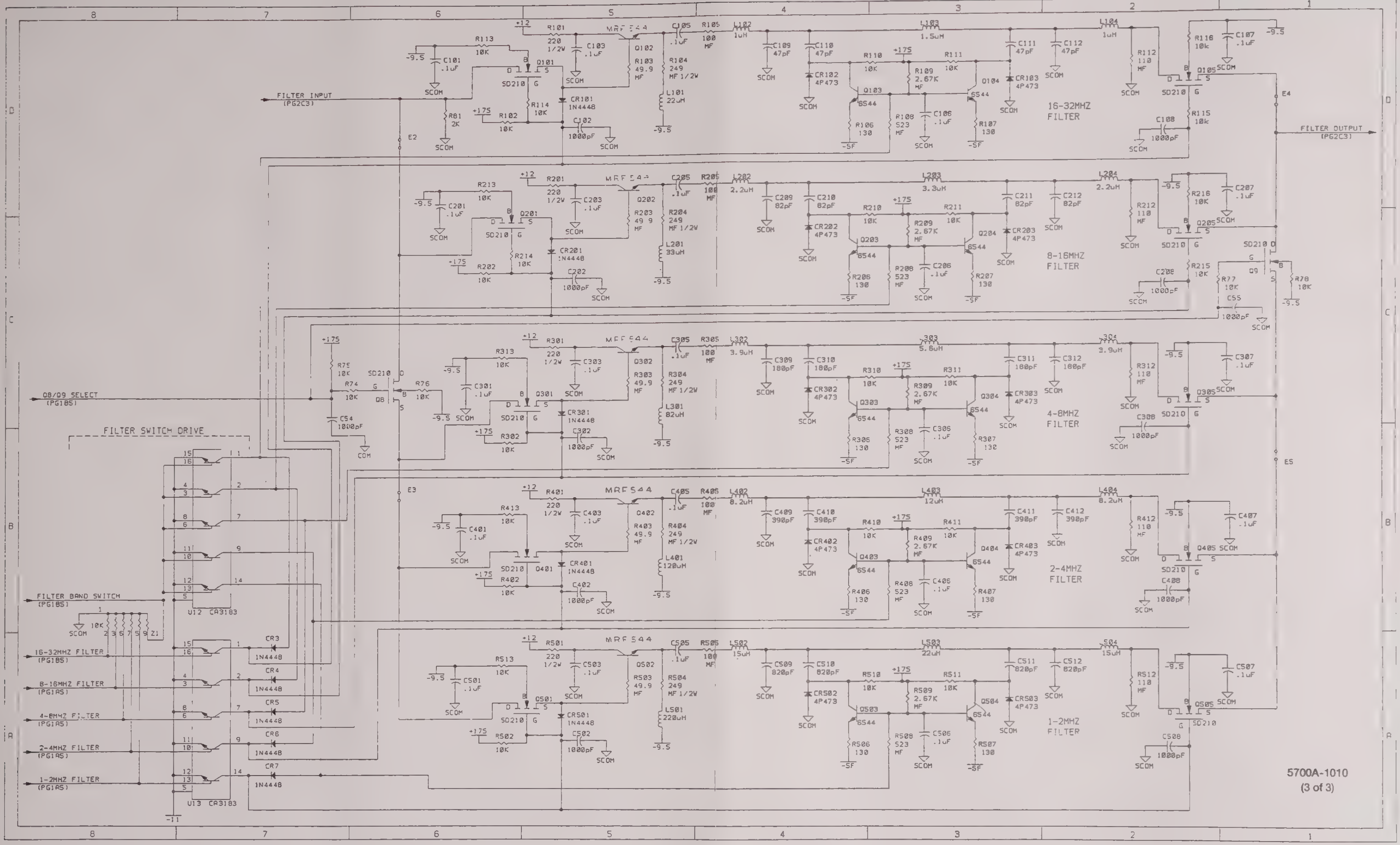


Figure 7-6. A6 Wideband Oscillator PCA (Option -03) (cont)

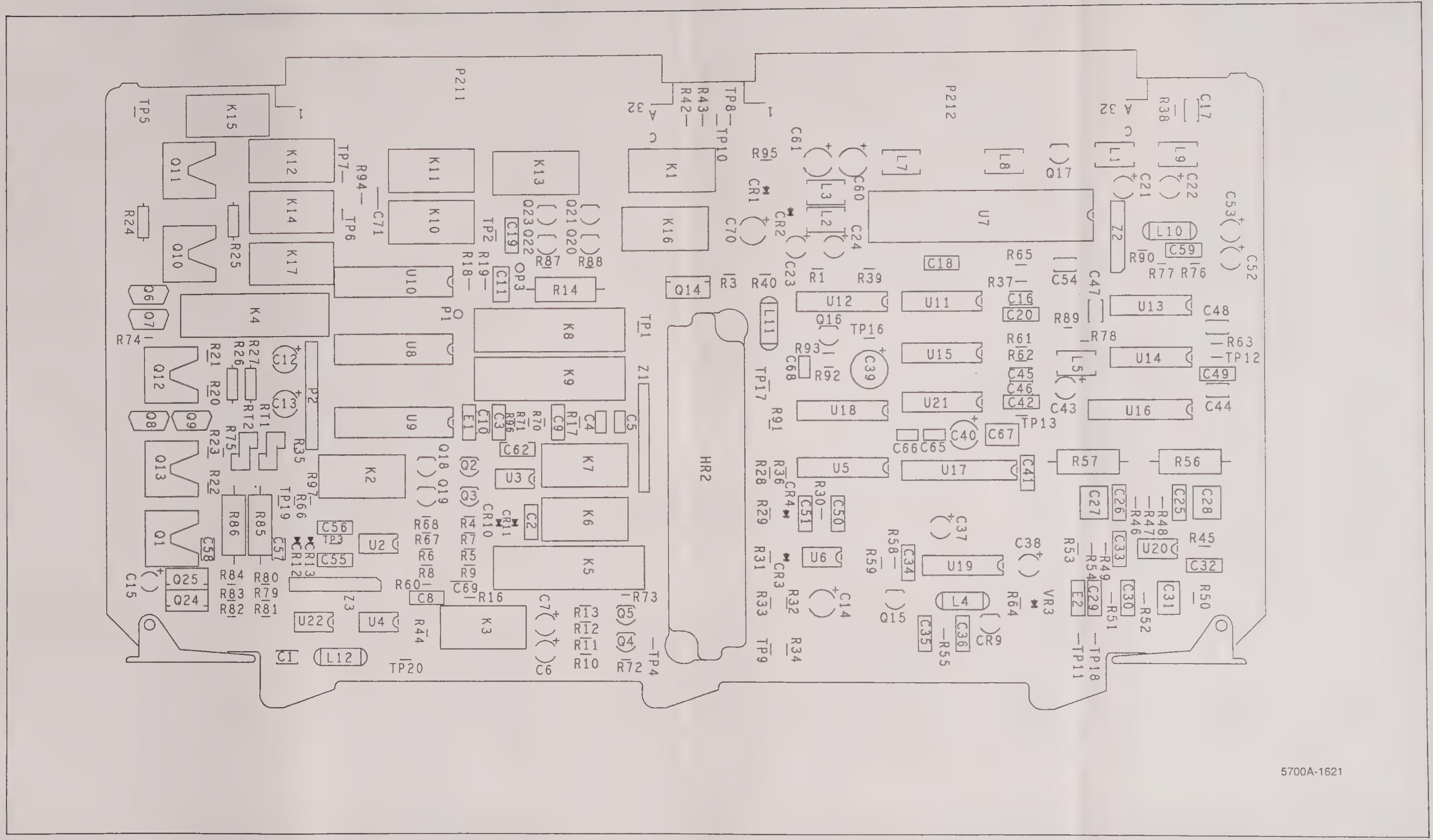
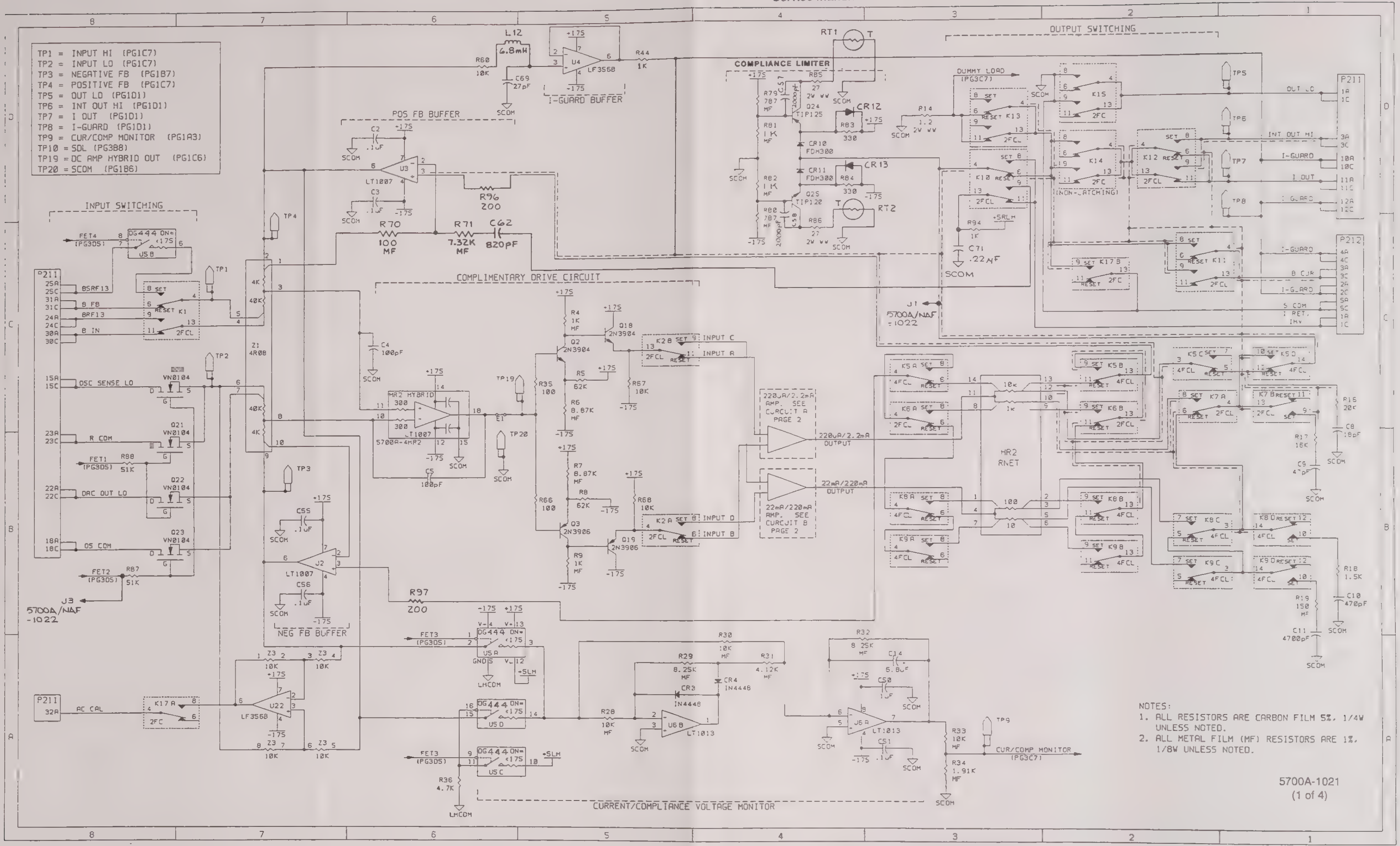


Figure 7-7. A7 Current/High-Resolution Oscillator PCA



TP1 = INPUT HI (PG1C7)
TP2 = INPUT LO (PG1C7)
TP3 = NEGATIVE FB (PG1B7)
TP4 = POSITIVE FB (PG1C7)
TP5 = OUT LO (PG1D1)
TP6 = INT OUT HI (PG1D1)
TP7 = I OUT (PG1D1)
TP8 = I-GUARD (PG1D1)
TP9 = CUR/COMP MONITOR (PG1A3)
TP10 = SDL (PG3B8)
TP19 = DC AMP HYBRID OUT (PG1C6)
TP20 = SCOM (PG1B6)

NOTES:
1. ALL RESISTORS ARE CARBON FILM 5%, 1/4W UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.

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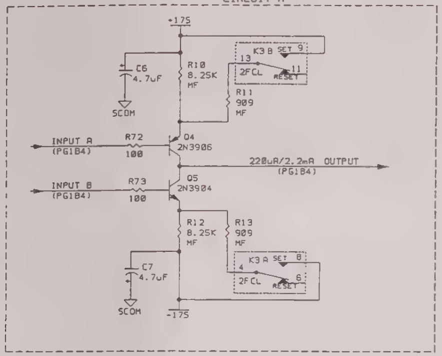
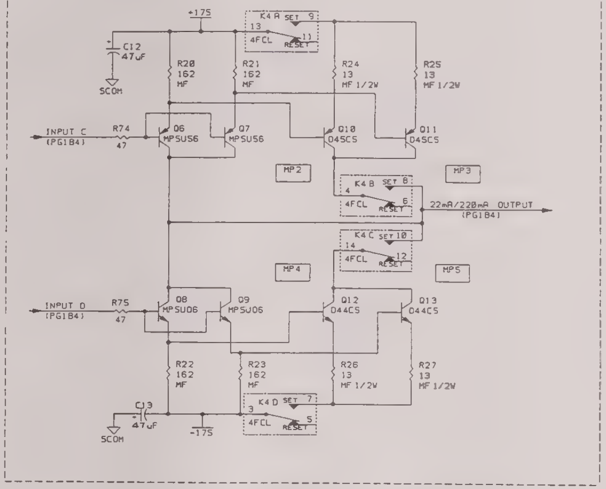
Figure 7-7. A7 Current/High-Resolution Oscillator PCA (cont)

220UA/2.2mA AMP
CIRCUIT A



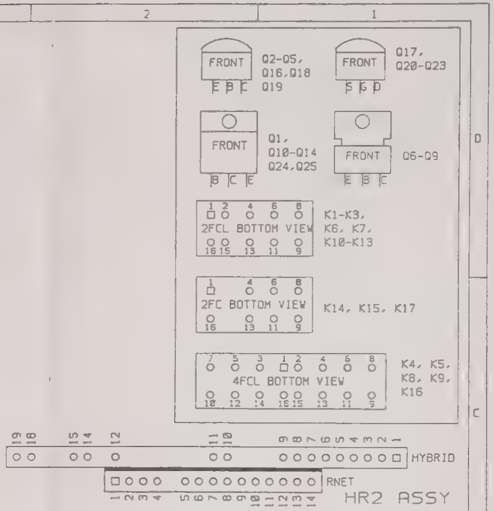
22mA/220mA AMP
CURCUIT B

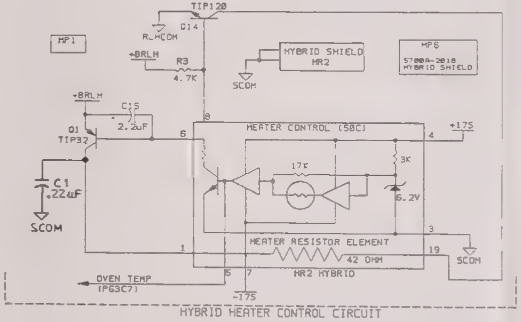


	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	Q20/Q23	Q21/Q22	U5A/U5C	U5D
PWR-UP / RESET																					
DC 220uA RANGE														■	■				■		
DC 2.2mA RANGE			S		S	S	S							■	■				■		
DC 22mA RANGE		S			S			S						■	■				■		
DC 220mA RANGE		S		S	S				S					■	■				■		
DC 2.2A RANGE		S			S					S	S			■	■				■		
AC 220uA RANGE														■	■			■			
AC 2.2mA RANGE			S		S	S	S							■	■			■			
AC 22mA RANGE		S			S			S						■	■			■			
AC 220mA RANGE		S		S	S				S					■	■			■			
AC 2.2A RANGE		S			S					S	S			■	■			■			

ALL RELAYS SHOWN IN THE RESET OR NON-LATCHING POSITION
S = SET POSITION OF LATCHING RELAYS
■ = ENERGIZED FOR NON-LATCHING RELAYS
■ = ON FOR FETS
K1 IS SET DURING CURRENT GAIN CALIBRATION
K12 IS SET WHEN CURRENT OUTPUT IS AT THE OUT HI BINDING
POST OR RESET WHEN CURRENT OUTPUT IS AT THE AUX I OUT
BINDING POST
K13 CONNECTS A DUMMY LOAD TO THE OUTPUT CURRENT WHEN RESET.
THIS IS DONE DURING DIAGNOSTICS AND CURRENT RANGE
SWITCHING

K16 IS SET DURING BOOST AMPLIFIER CALIBRATION
K17 IS ENERGIZED DURING AC CURRENT FLATNESS CHARACTERIZATION





HYBRID HEATER CONTROL CIRCUIT

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Figure 7-7. A7 Current/High-Resolution Oscillator PCA (cont)

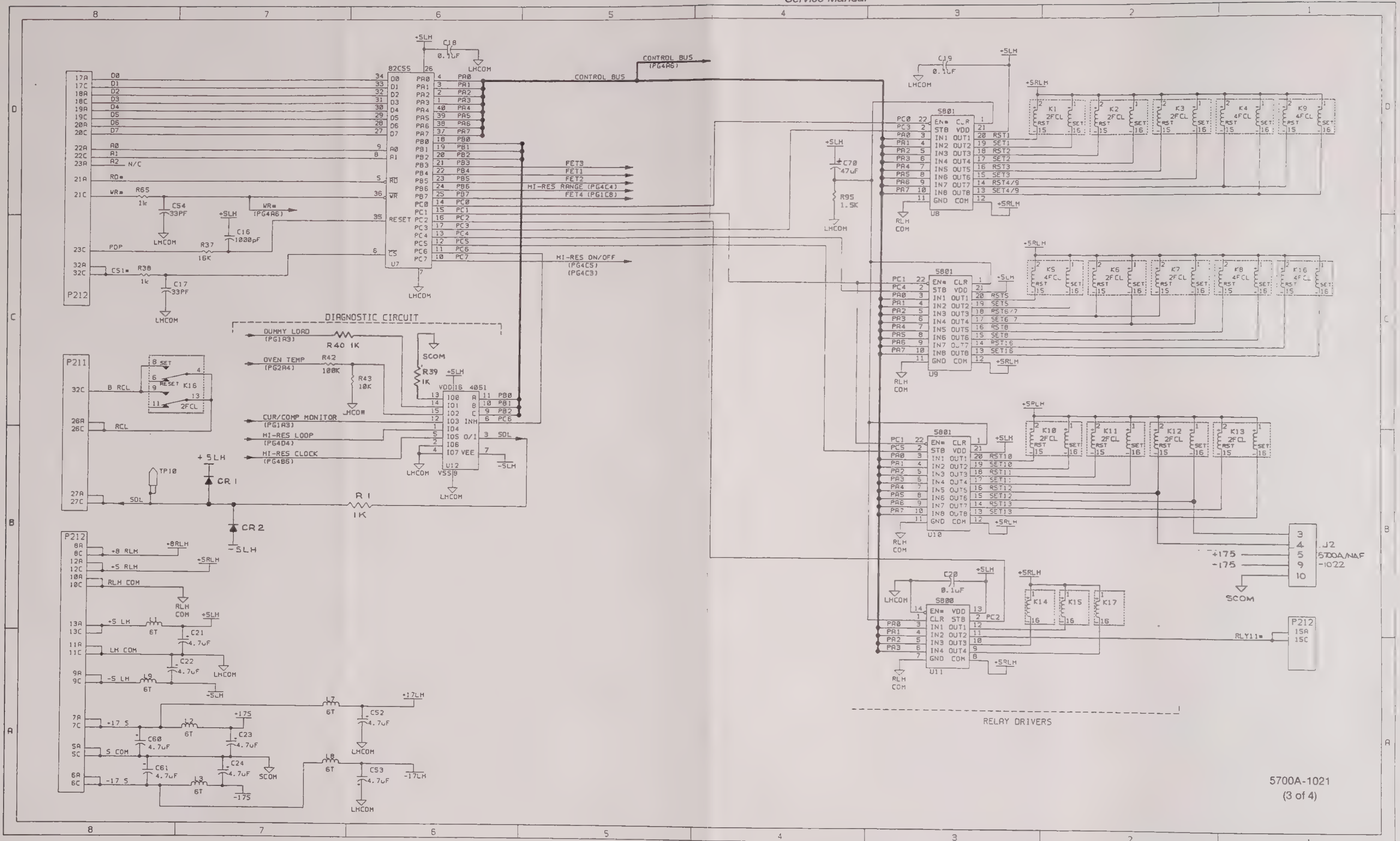
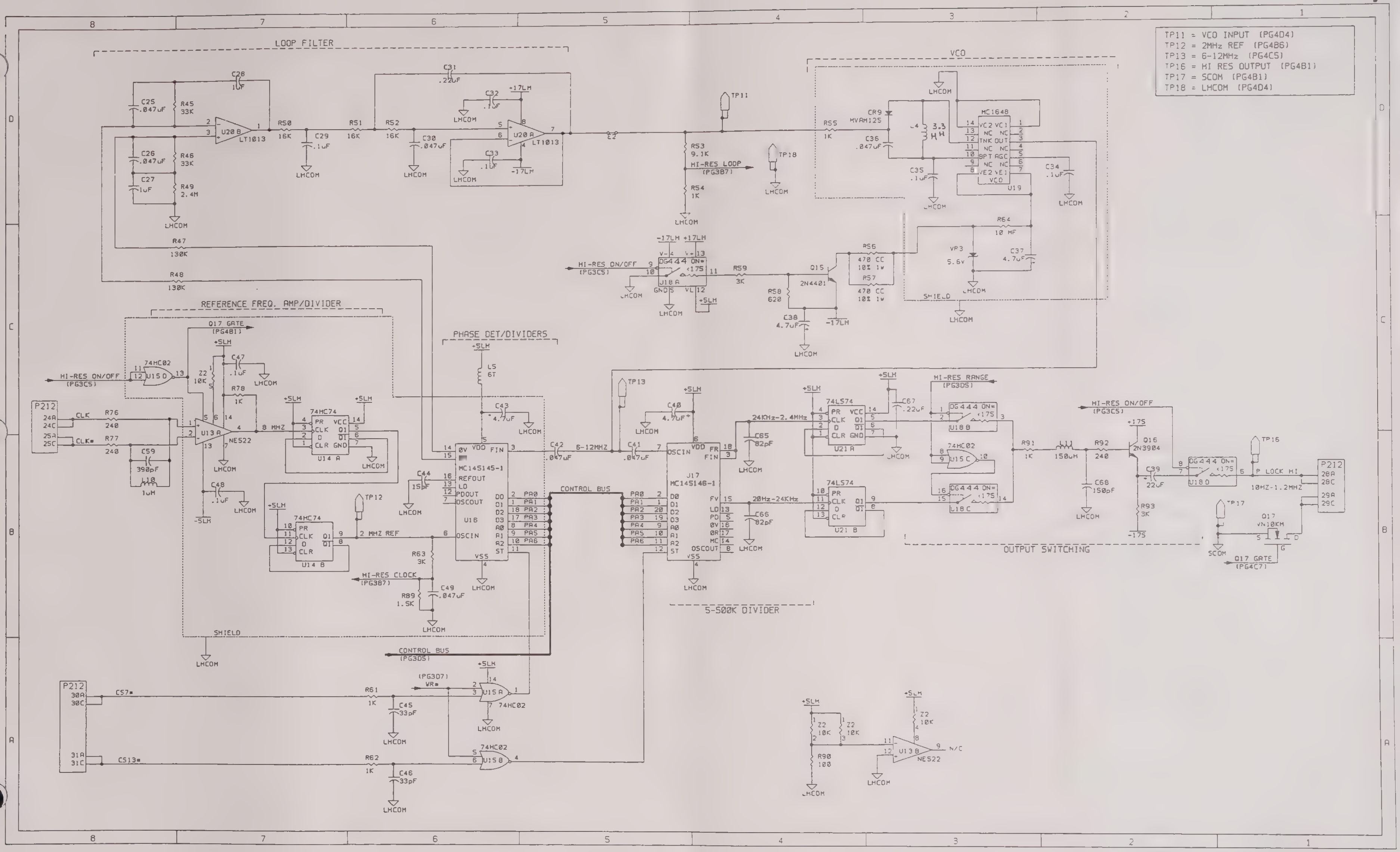


Figure 7-7. A7 Current/High-Resolution Oscillator PCA (cont)



TP11 = VCO INPUT (PG4D4)
TP12 = 2MHz REF (PG4B6)
TP13 = 6-12MHz (PG4C5)
TP16 = HI RES OUTPUT (PG4B1)
TP17 = SCOM (PG4B1)
TP18 = LHCOM (PG4D4)

Figure 7-7. A7 Current/High-Resolution Oscillator PCA (cont)

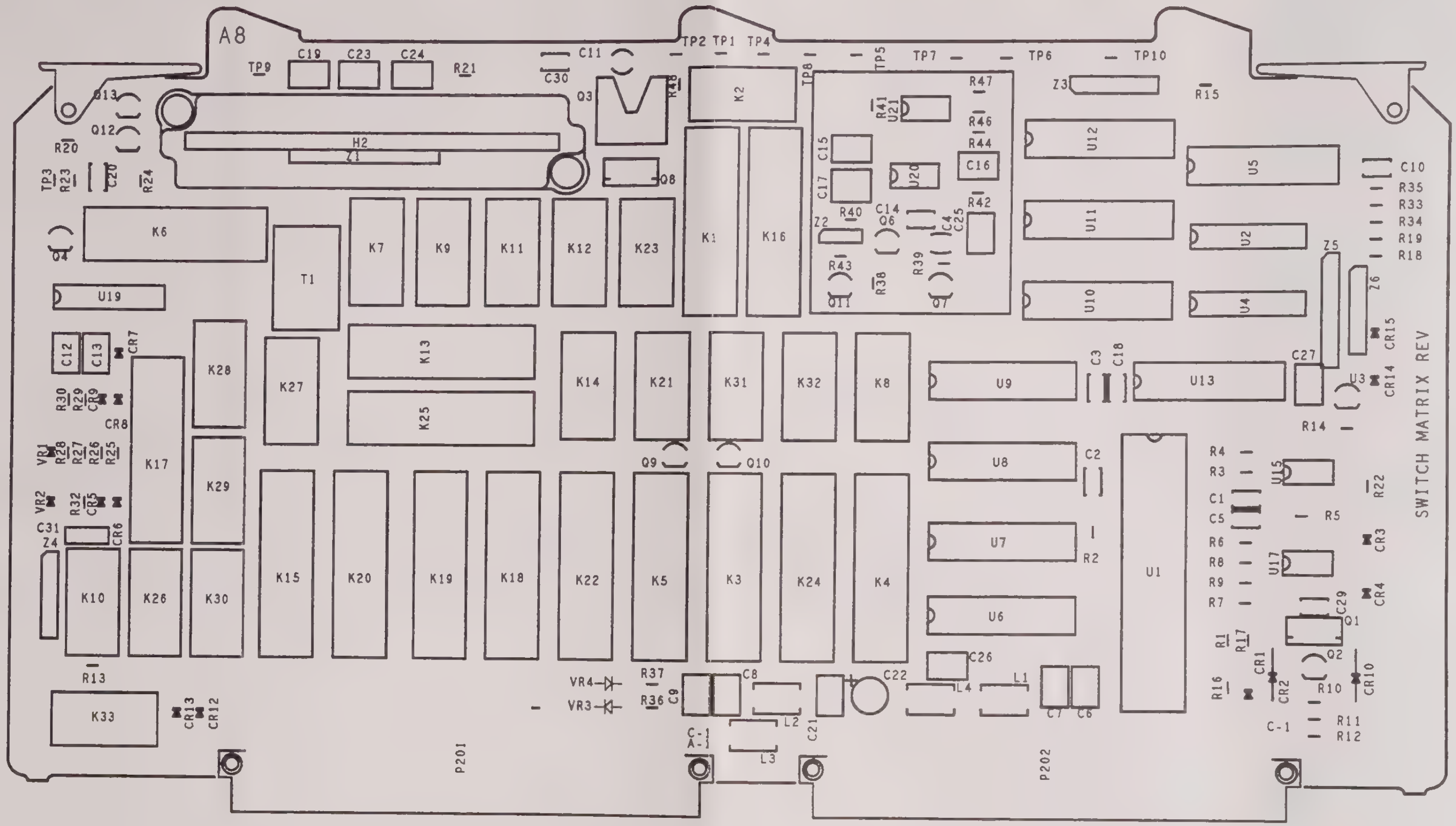


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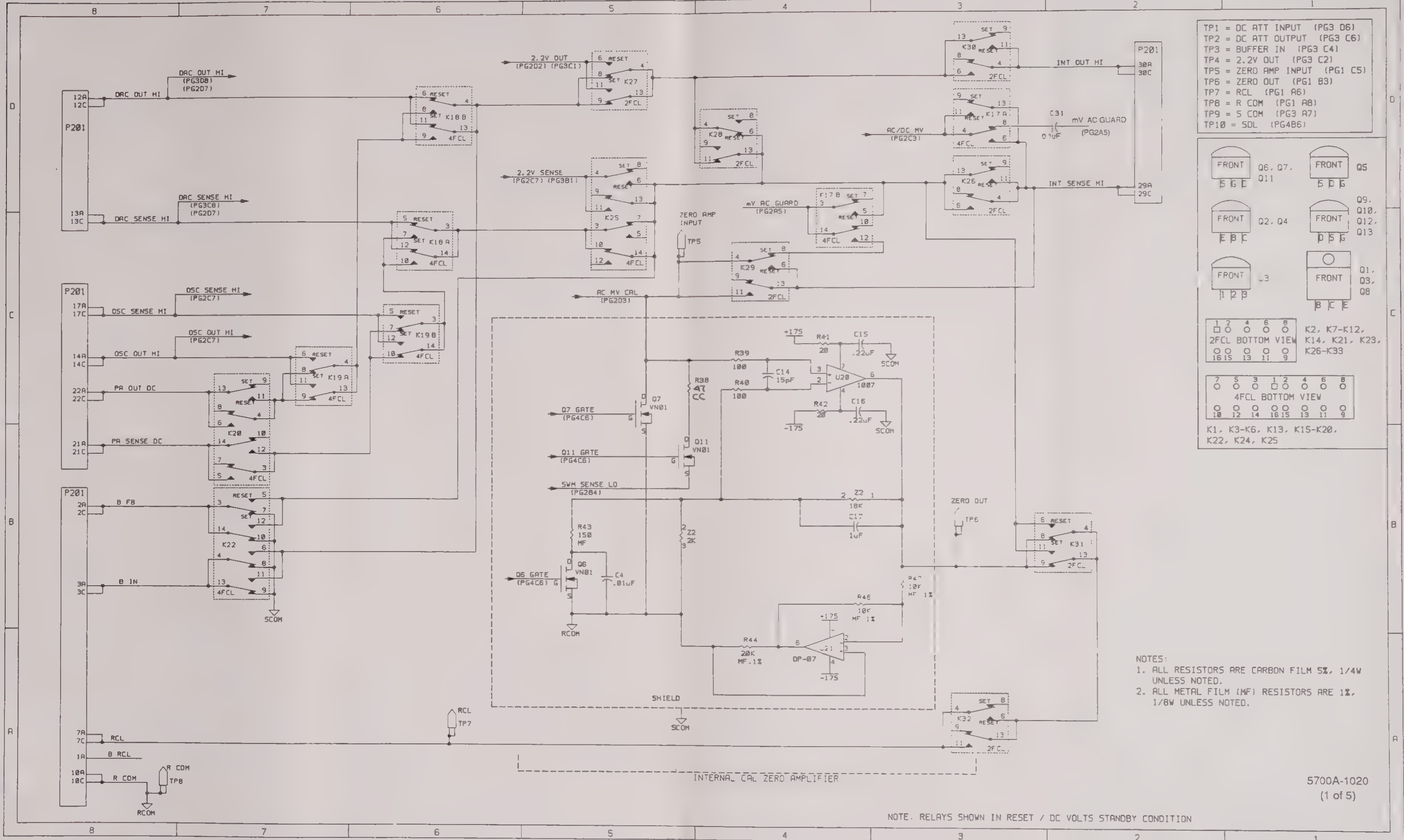
Figure 7-8. A8 Switch Matrix PCA



TP1 = DC ATT INPUT (PG3 D6)
TP2 = DC ATT OUTPUT (PG3 C6)
TP3 = BUFFER IN (PG3 C4)
TP4 = 2.2V OUT (PG3 C2)
TP5 = ZERO AMP INPUT (PG1 C5)
TP6 = ZERO OUT (PG1 B3)
TP7 = RCL (PG1 A6)
TP8 = R COM (PG1 A8)
TP9 = S COM (PG3 A7)
TP10 = SDL (PG4B6)

NOTES:
1. ALL RESISTORS ARE CARBON FILM 5%, 1/4W UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.

NOTE. RELAYS SHOWN IN RESET / DC VOLTS STANDBY CONDITION

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Figure 7-8. A8 Switch Matrix PCA (cont)

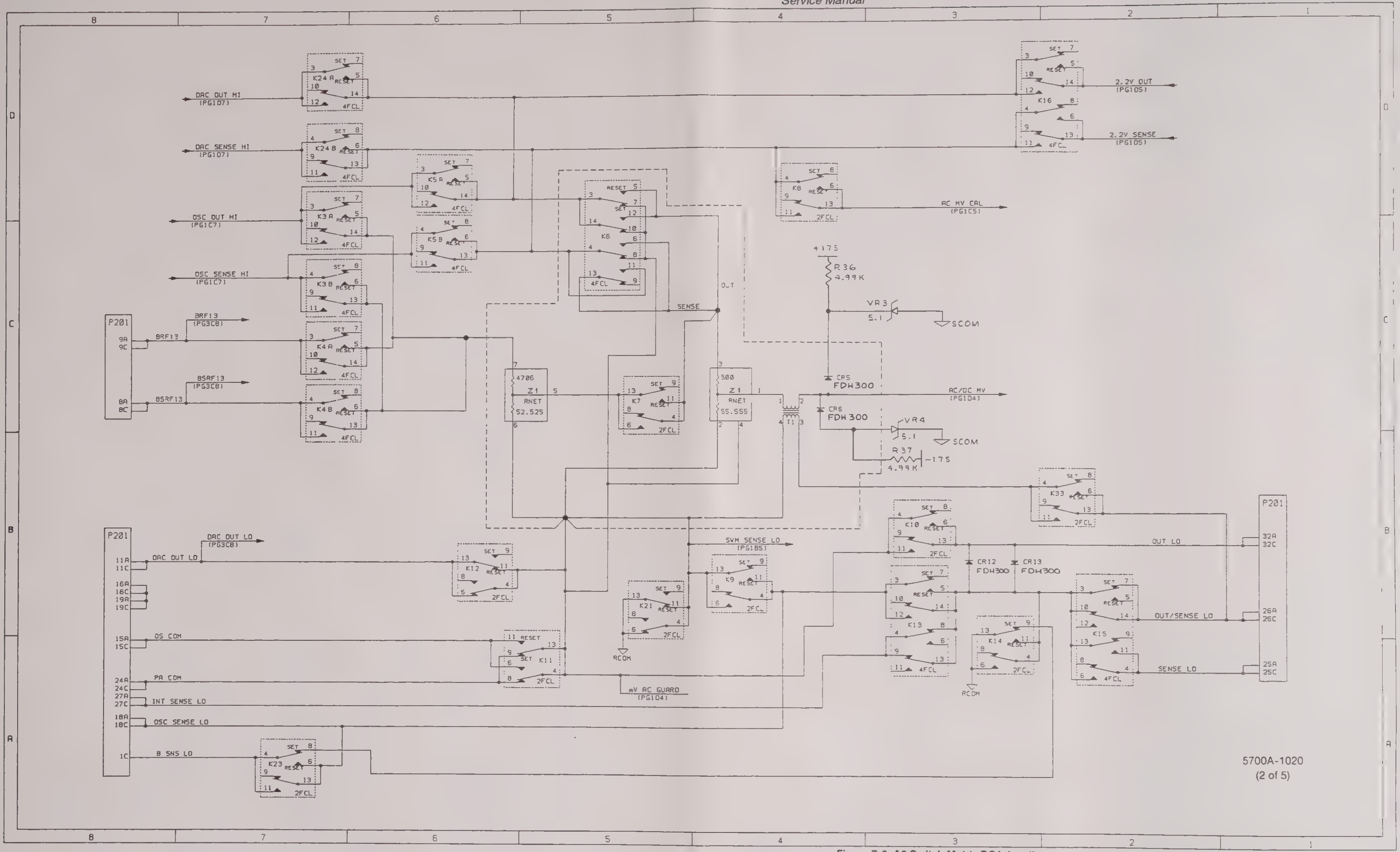

Figure 7-8. A8 Switch Matrix PCA (cont)

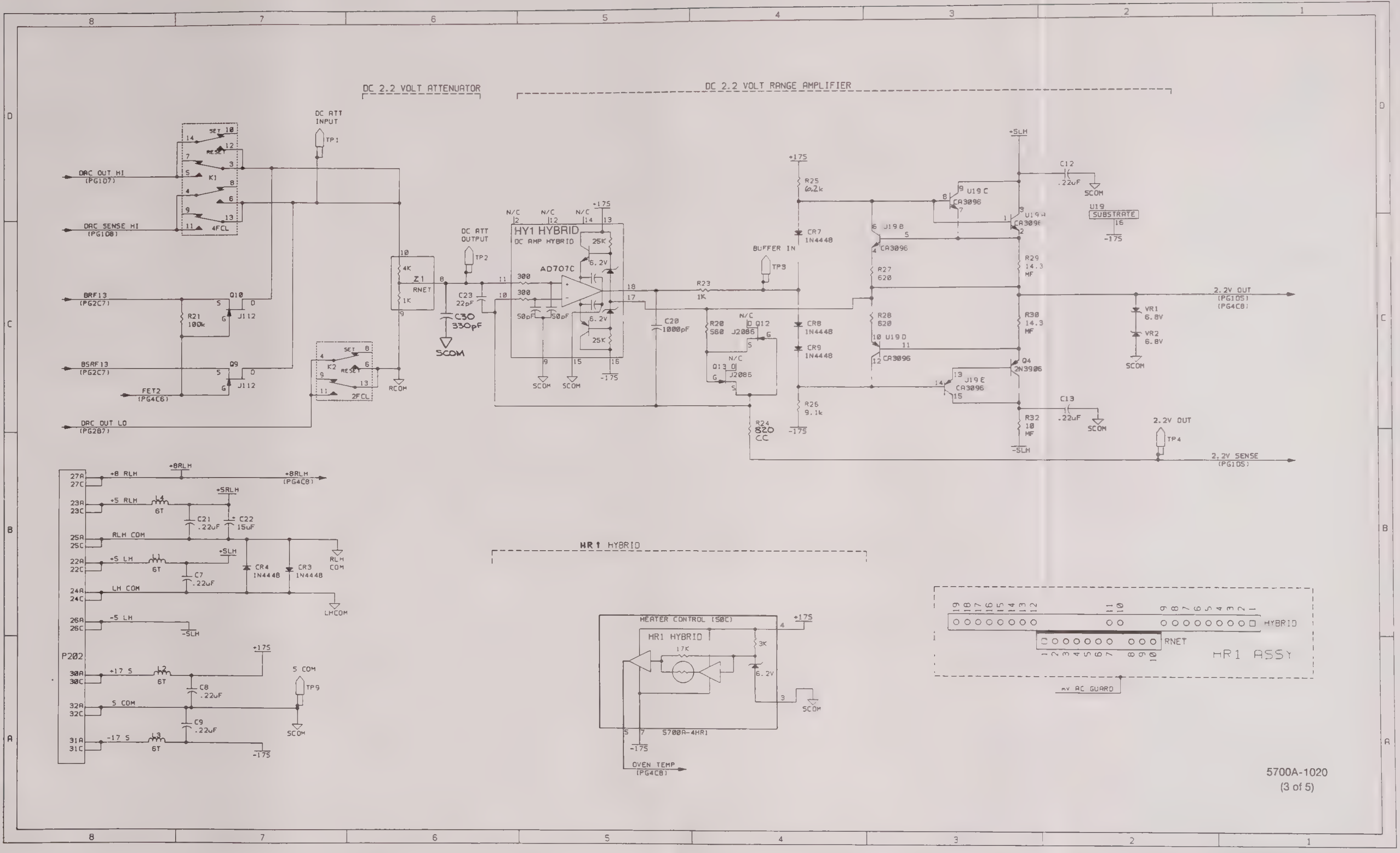

Figure 7-8. A8 Switch Matrix PCA (cont)

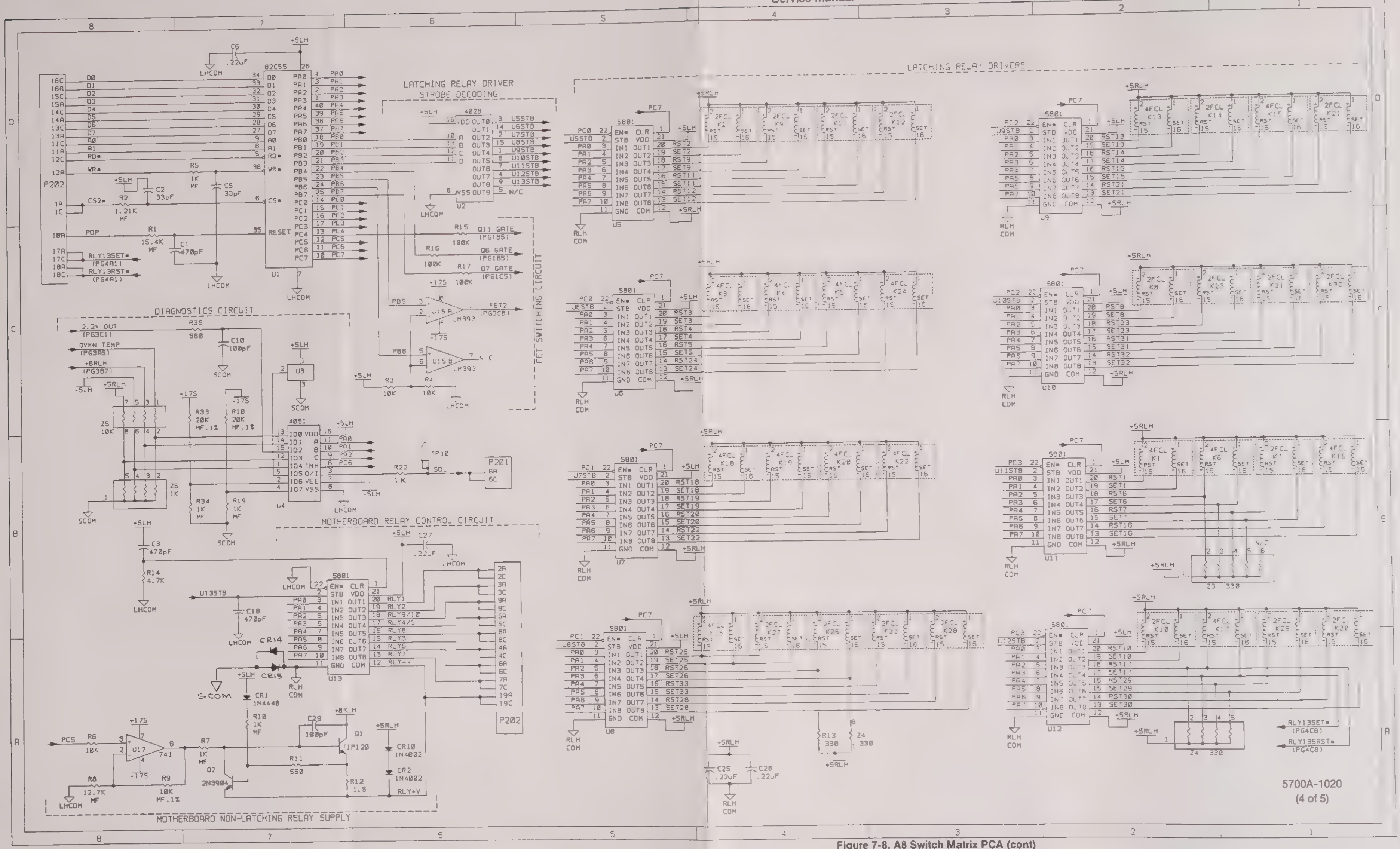

Figure 7-8. A8 Switch Matrix PCA (cont)

	SWITCH MATRIX RELAYS AND FETS																																					MOTHERBOARD RELAYS								
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20	K21	K22	K23	K24	K25	K26	K27	K28	K29	K30	K31	K32	K33	Q6	Q7	Q9/Q10	Q11	K1	K2	K3	K4/K5	K6	K7	K8	K9/K10	K13
RESET / DC VOLTS STANDBY												R						R			R							R							■											
DC 220mV RANGE	R	R				R										R	R				R												R						■			■	■	■		R
DC 2.2V RANGE	R	R								R				R	E										R	R	R			R					■			■	■	E		■	■	■		
DC 11V/22V RANGE										R		R		R	E			R								R				R					■			■	■	E		■	■	■		
DC 220V RANGE										R		R		R	E					R						R				R					■			■	■	E		■	■	■		
DC 1100V RANGE										R		R		R	E																				■					E		■	■	■	■	
DC 1100V 5205 MODE													R						R				R	R											■											
AC VOLTS STANDBY									R		R								R									R							■											
AC 2.2mV RANGE			R				R		R		R				R		R																R						■			■	■	■		R
AC 22mV RANGE			R				R		R		R				R		R																R						■			■	■	■		R
AC 220mV RANGE					R	R			R		R				R		R																R						■			■	■	■		R
AC 2.2V/22V RANGE										R	R		R		E				R							R				R					■			■	■	E		■	■	■		
AC 220V RANGE										R			R		E																				■					E		■	■	■	■	
AC 1100V RANGE										R			R		E																				■					E		■	■	■	■	
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20	K21	K22	K23	K24	K25	K26	K27	K28	K29	K30	K31	K32	K33	Q6	Q7	Q9/Q10	Q11	K1	K2	K3	K4/K5	K6	K7	K8	K9/K10	
AC 1100V BOOST MODE										R			R						R			R													■						■					
AC 1100V 5205 MODE												R		R				R				R	R		R		R								■											
BOOST DC CURRENT MODE	R	R										R										R			R		R	R							■											
BOOST AC CURRENT MODE									R										R			R	R												■											
DC 11V RANGE ZERO CAL												R						R			R					R		R	R			R		■												
CAL 10V DC TO EXT 10V STD										R		R		R												R					R	R			■				■							
2.2V RANGE OFFSET CAL	R	R										R													R	R	R	R	R			R		■												
2.2V RANGE GAIN CAL		R										R													R		R	R	R		R	R			■	■										
220mV RANGE CHECKPOINT	R	R				R										R					R											R		■			■									R
220mV RANGE OFFSET CAL	R	R				R										R	R				R								R			R		■												R
220mV RANGE GAIN CAL						R						R					R				R			R					R			R														R
22mV RANGE GAIN CAL				R		R	R	R				R						R			R							R				R														
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20	K21	K22	K23	K24	K25	K26	K27	K28	K29	K30	K31	K32	K33	Q6	Q7	Q9/Q10	Q11	K1	K2	K3	K4/K5	K6	K7	K8	K9/K10	

R = RESET POSITION FOR ALL LATCHING RELAYS
■ = ENERGIZED FOR NON-LATCHING RELAYS
■ = ON FOR FETS
E = EXTERNAL SENSE STATE FOR K15 RESET AND MOTHERBOARD RELAY K3 ENERGIZED

THE SCHEMATIC IS SHOWN WITH THE RELAYS IN THE RESET / DC VOLTS STANDBY CONDITION

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Figure 7-8. A8 Switch Matrix PCA (cont)

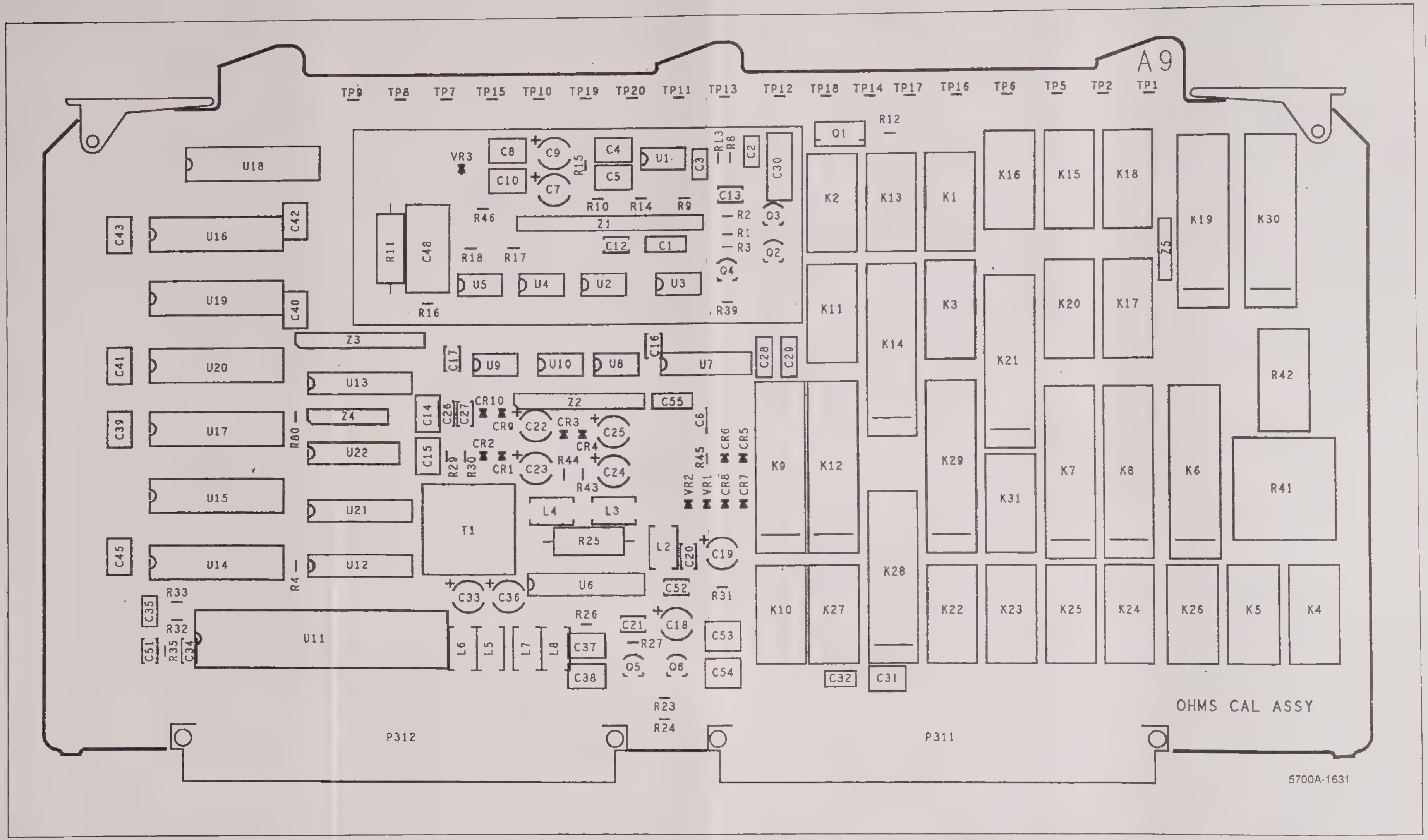
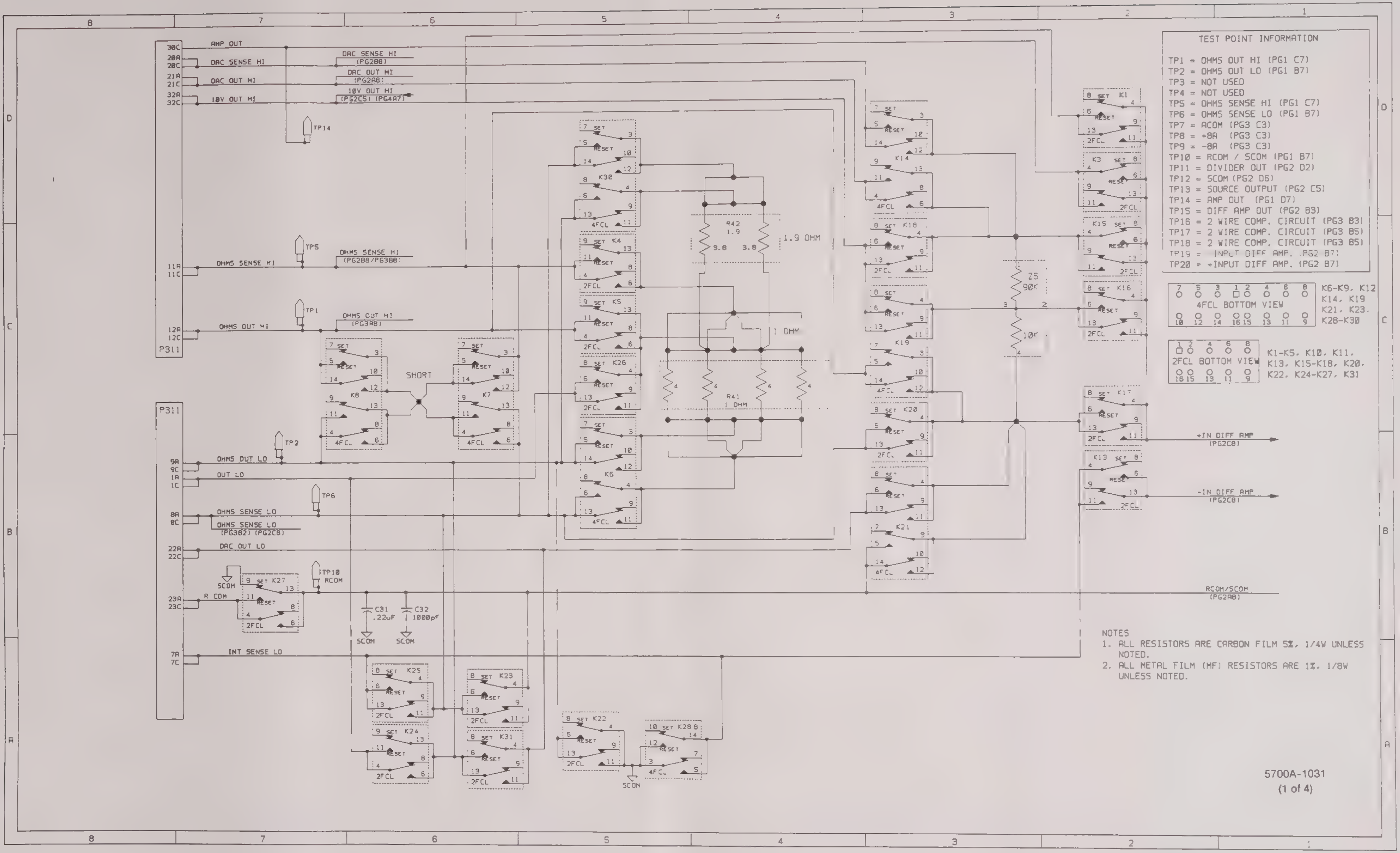


Figure 7-9 A9 Ohms Cal PCA



TEST POINT INFORMATION

TP1 = OHMS OUT HI (PG1 C7)
TP2 = OHMS OUT LO (PG1 B7)
TP3 = NOT USED
TP4 = NOT USED
TP5 = OHMS SENSE HI (PG1 C7)
TP6 = OHMS SENSE LO (PG1 B7)
TP7 = ACOM (PG3 C3)
TP8 = +8A (PG3 C3)
TP9 = -8A (PG3 C3)
TP10 = RCOM / SCOM (PG1 B7)
TP11 = DIVIDER OUT (PG2 D2)
TP12 = SCOM (PG2 D6)
TP13 = SOURCE OUTPUT (PG2 C5)
TP14 = AMP OUT (PG1 D7)
TP15 = DIFF AMP OUT (PG2 B3)
TP16 = 2 WIRE COMP. CIRCUIT (PG3 B3)
TP17 = 2 WIRE COMP. CIRCUIT (PG3 B5)
TP18 = 2 WIRE COMP. CIRCUIT (PG3 B5)
TP19 = -INPUT DIFF AMP. (PG2 B7)
TP20 = +INPUT DIFF AMP. (PG2 B7)

4FCL BOTTOM VIEW: K6-K9, K12, K14, K19, K21, K23, K28-K30

2FCL BOTTOM VIEW: K1-K5, K10, K11, K13, K15-K18, K20, K22, K24-K27, K31

NOTES
1. ALL RESISTORS ARE CARBON FILM 5%, 1/4W UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.

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Figure 7-9. A9 Ohms Cal PCA (cont)

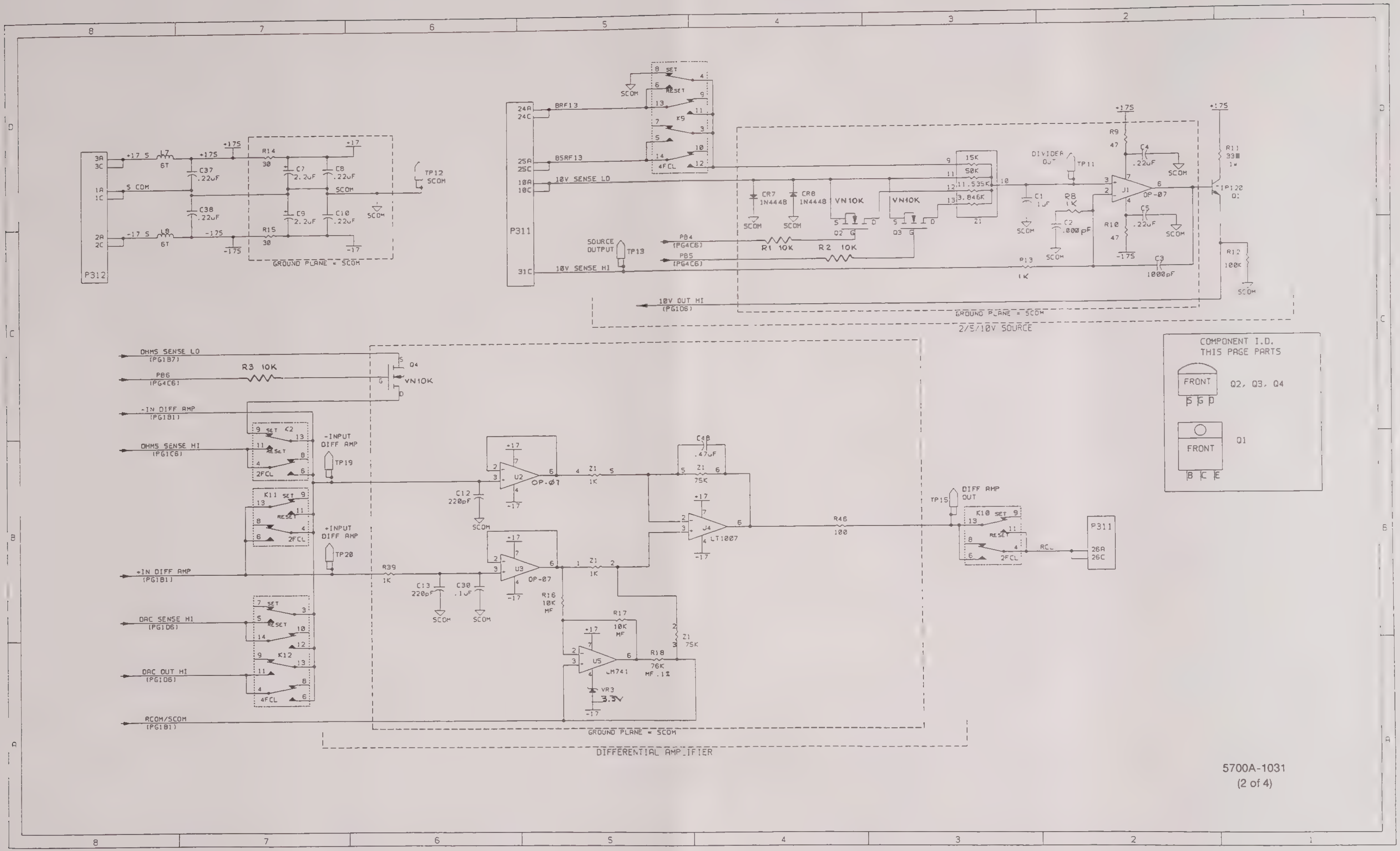


Figure 7-9. A9 Ohms Cal PCA (cont)

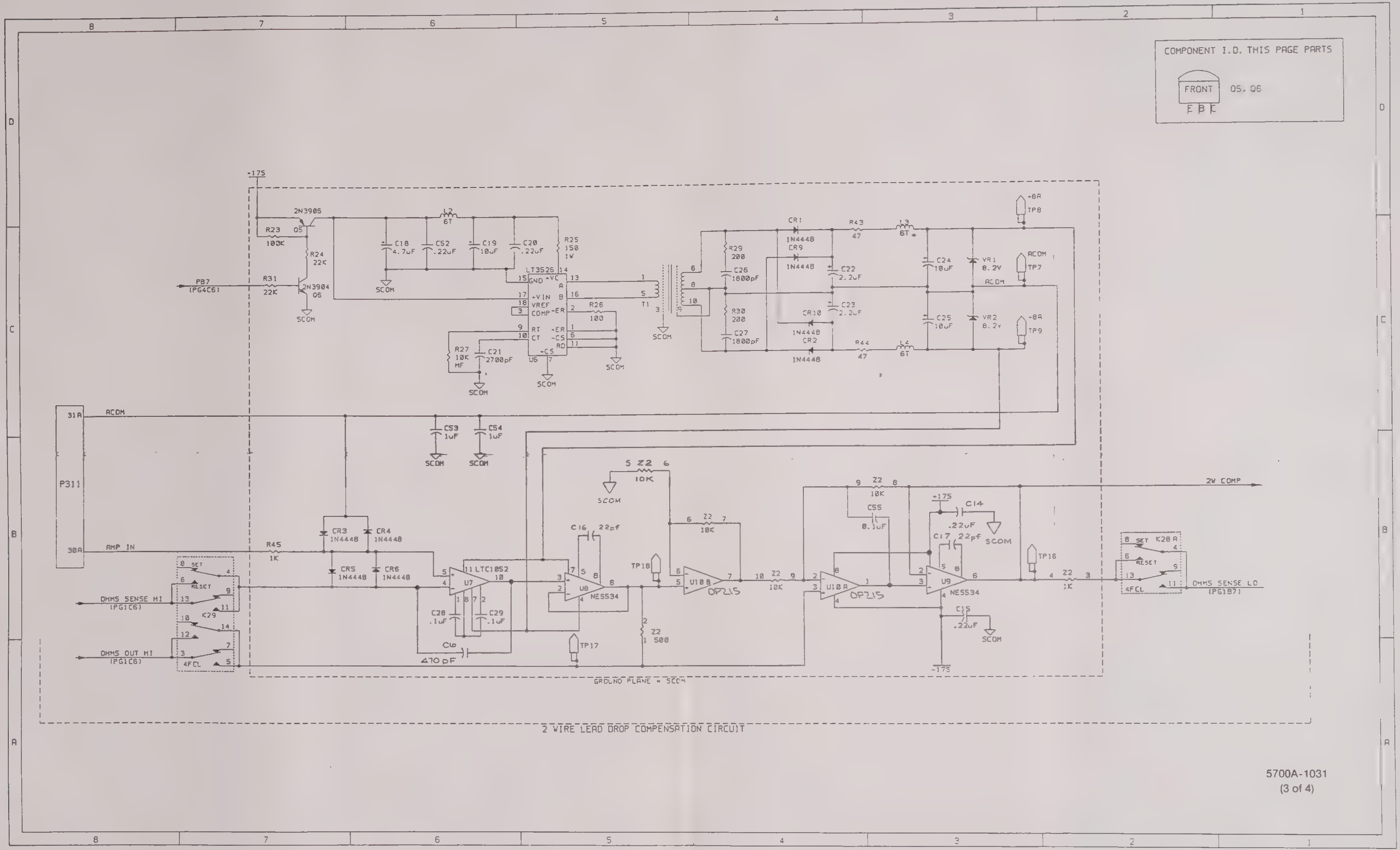


Figure 7-9. A9 Ohms Cal PCA (cont)

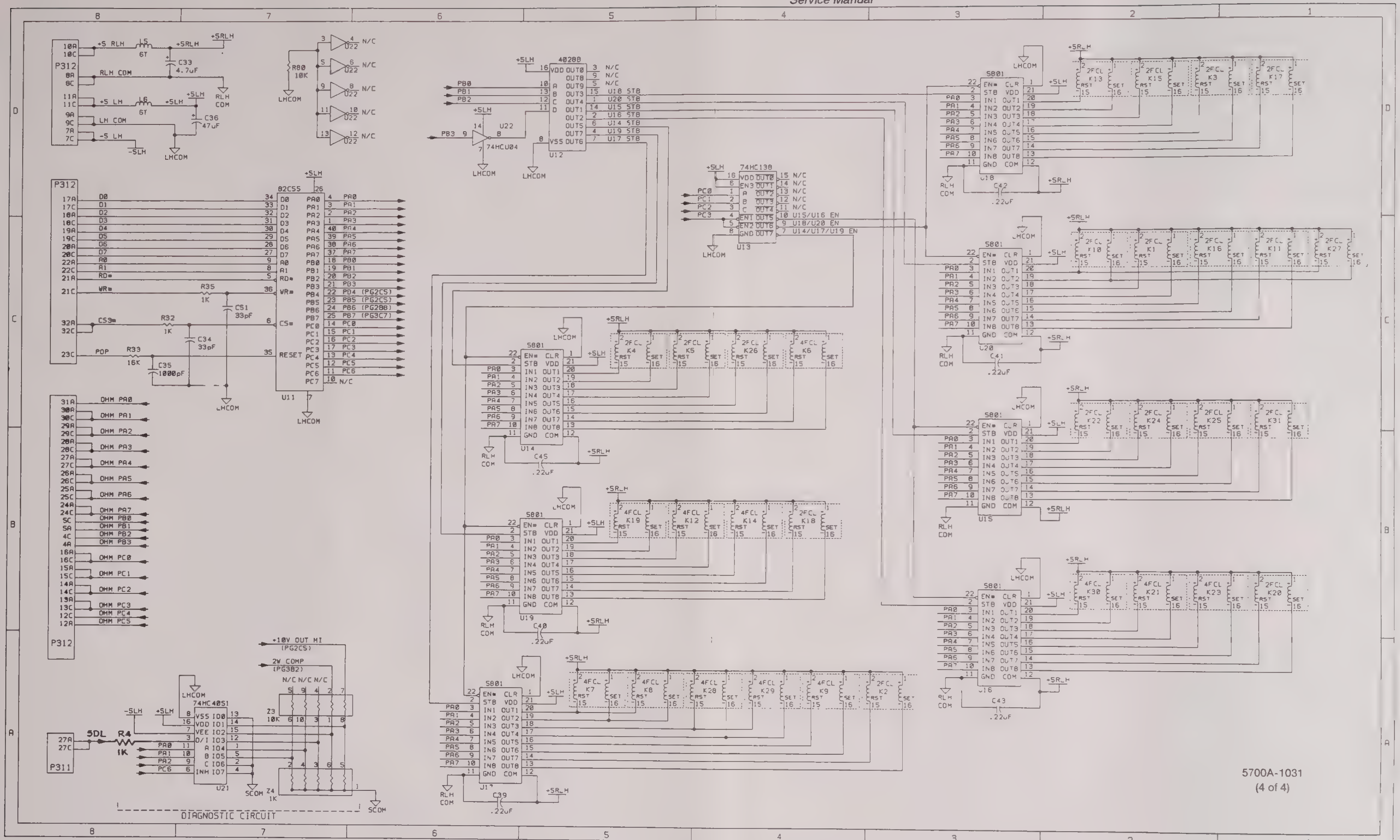


Figure 7-9. A9 Ohms Cal PCA (cont)

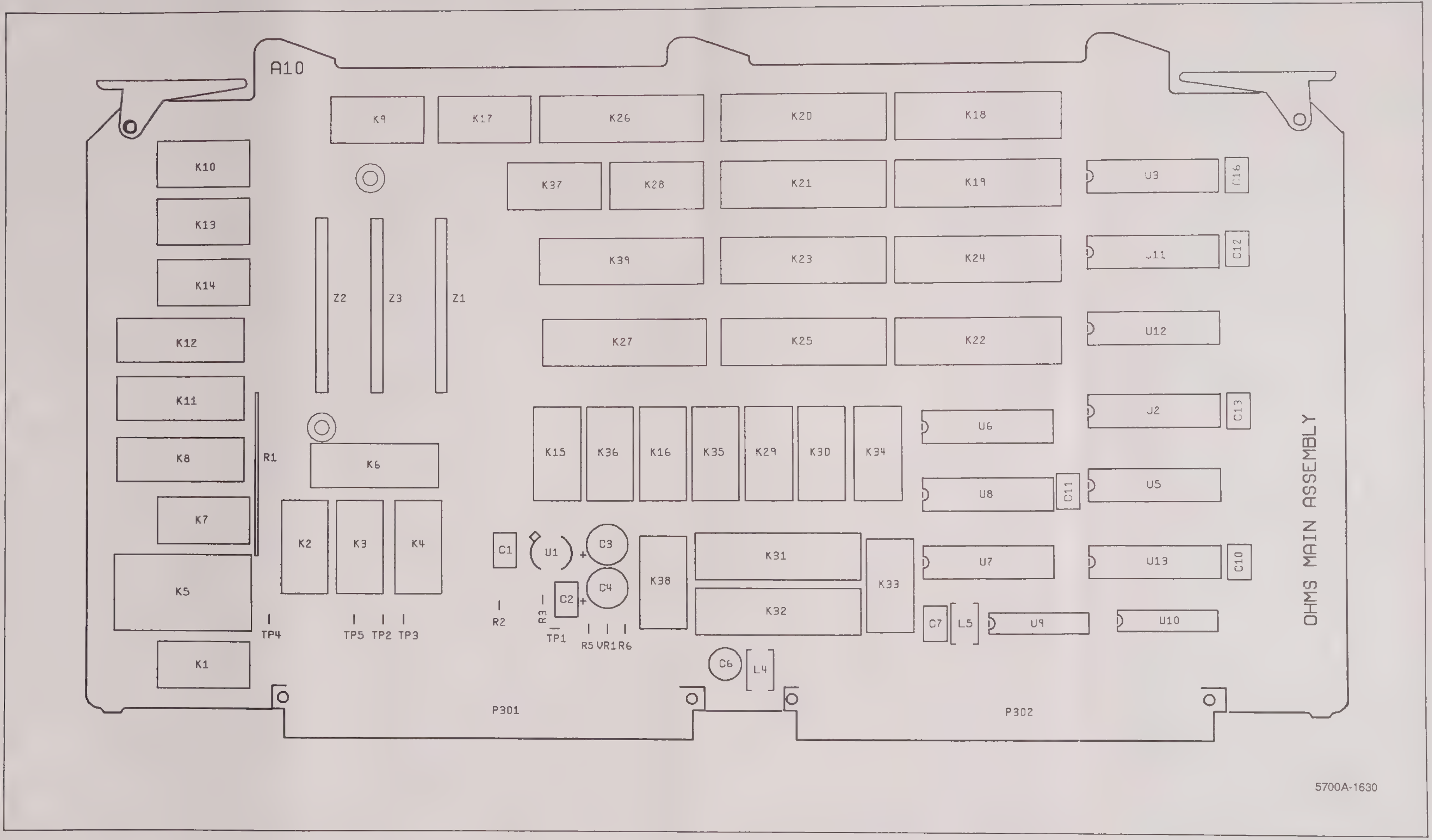
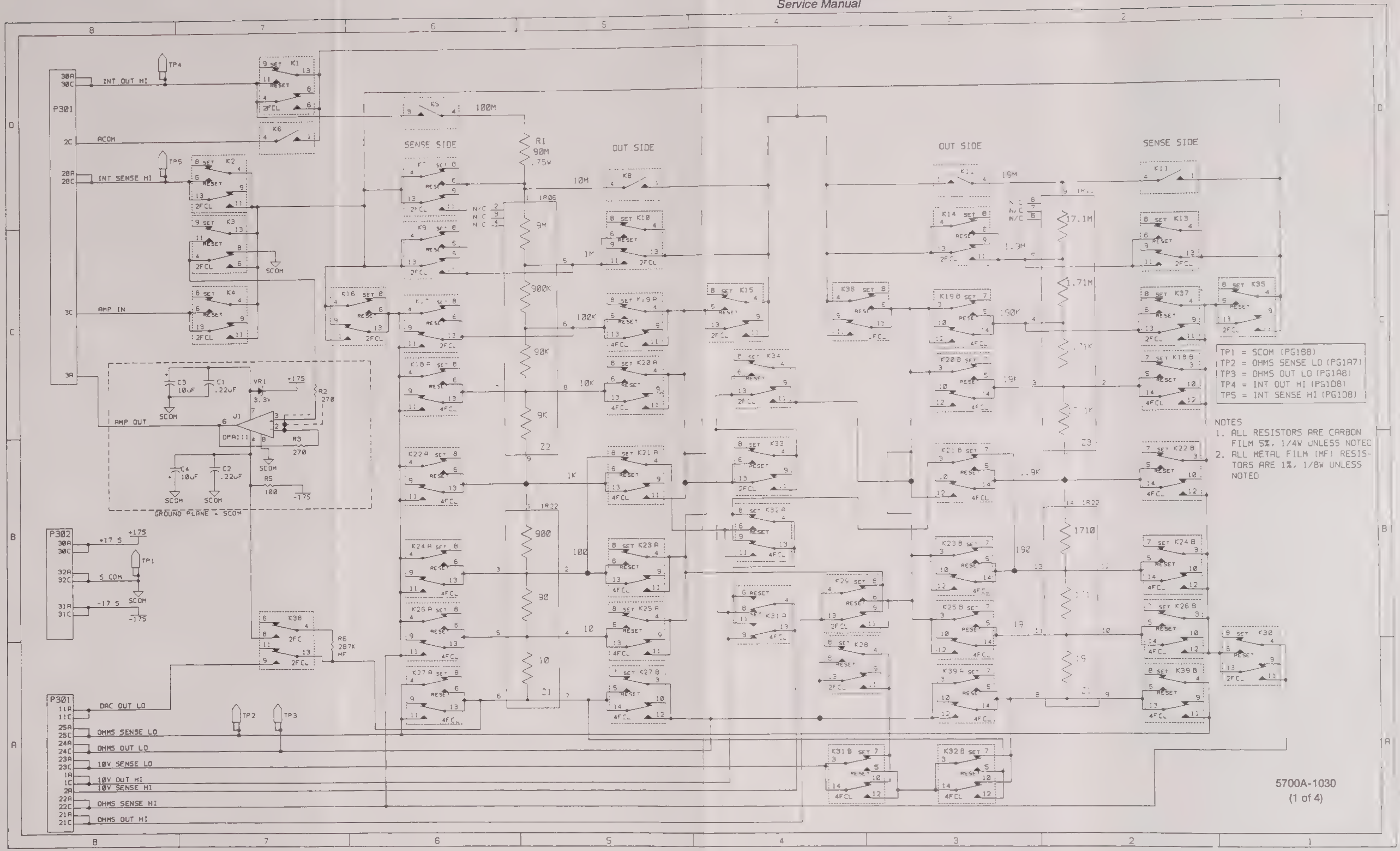


Figure 7-10. A10 Ohms Main PCA



TP1 = SCOM (PG1B8)
TP2 = OHMS SENSE LO (PG1A7)
TP3 = OHMS OUT LO (PG1A8)
TP4 = INT OUT HI (PG1D8)
TP5 = INT SENSE HI (PG1D8)

NOTES
1. ALL RESISTORS ARE CARBON FILM 5%, 1/4W UNLESS NOTED
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED

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Figure 7-10. A10 Ohms Main PCA (cont)

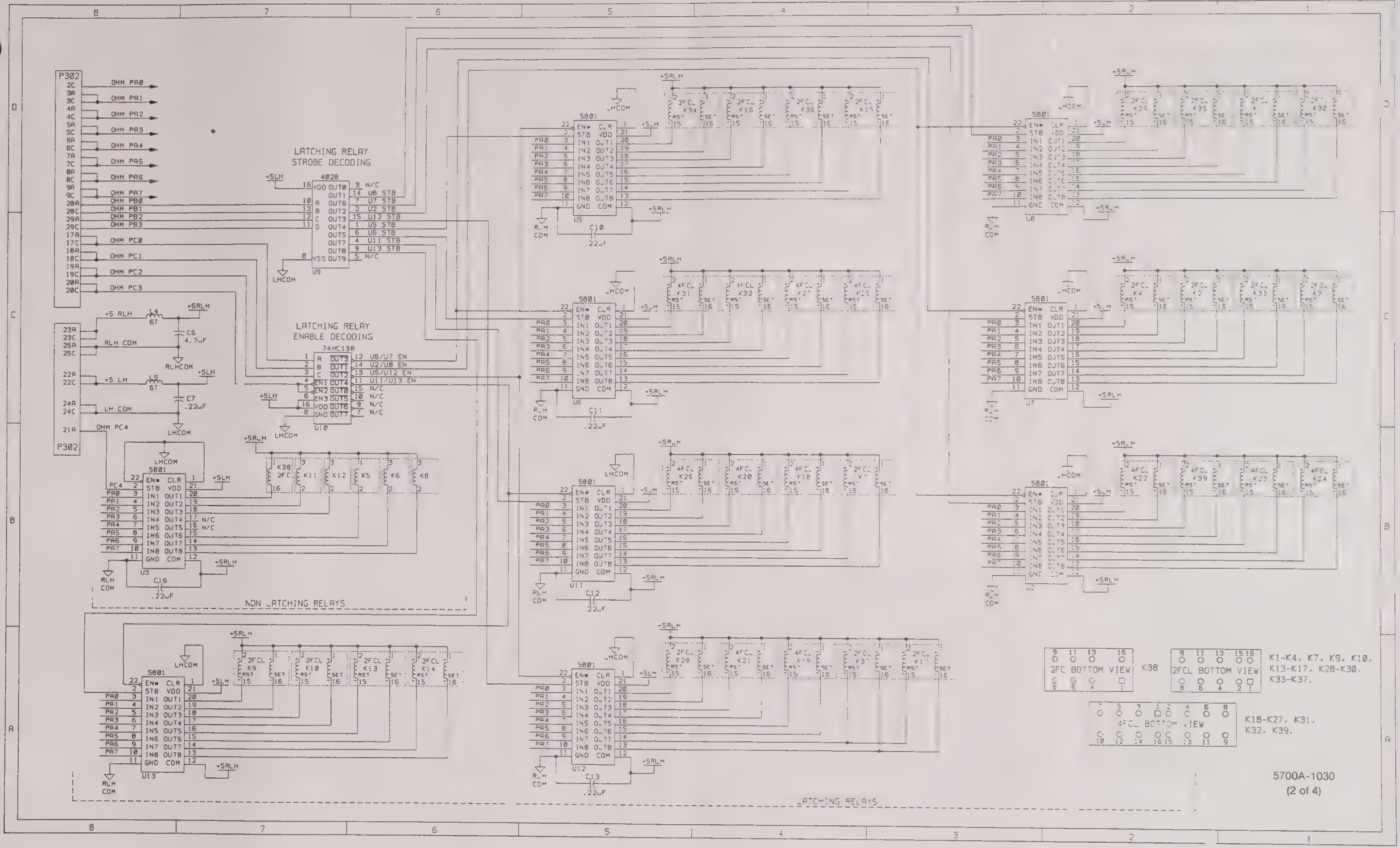

Figure 7-10. A10 Ohms Main PCA (cont)

OHMS MAIN ASSEMBLY RELAYS

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20	K21	K22	K23	K24	K25	K26	K27	K28	K29	K30	K31	K32	K33	K34	K35	K36	K37	K38	K39
DORMANT																																							
4 WIRE SHORT	R	R													R	R																							
4 WIRE 1 OHM	R	R													R	R																							
4 WIRE 1.9 OHM	R	R													R	R																							
4 WIRE 10 OHM	R	R													R	R									R	R	R												
4 WIRE 19 OHM	R	R																							R	R									R	R			R
4 WIRE 100 OHM	R	R													R	R							R	R			R												
4 WIRE 190 OHM	R	R																					R	R											R	R			R
4 WIRE 1K OHM	R	R													R	R					R	R					R												
4 WIRE 1.9K OHM	R	R																			R	R													R	R			R
4 WIRE 10K OHM	R	R													R	R		R		R							R												
4 WIRE 19K OHM	R	R																R		R															R	R			R
4 WIRE 100K OHM	R	R													R	R	R		R								R										R		
4 WIRE 190K OHM	R	R															R		R																R	R	R		R
4 WIRE 1M OHM	R	R							R	R																	R												
4 WIRE 1.9M OHM	R	R											R	R																									R
4 WIRE 10M OHM	R	R					R	■																			R												
4 WIRE 19M OHM	R	R									■	■																											R
2 WIRE 100M OHM					■																						R												
2 WIRE COMP. SHORT	R	R		R		■																																	
2 WIRE COMP. 1 OHM	R	R		R		■																																	
2 WIRE COMP. 1.9 OHM	R	R		R		■																																	
2 WIRE COMP. 10 OHM	R	R		R		■																			R	R	R												
2 WIRE COMP. 19 OHM	R	R		R		■																			R	R			R	R									R
2 WIRE COMP. 100 OHM	R	R		R		■																	R	R			R												
2 WIRE COMP. 190 OHM	R	R		R		■																	R	R					R	R									R
2 WIRE COMP. 1K OHM	R	R		R		■															R	R					R												
2 WIRE COMP. 1.9K OHM	R	R		R		■															R	R							R	R									R
2 WIRE COMP. 10K OHM	R	R		R		■												R		R							R												
2 WIRE COMP. 19K OHM	R	R		R		■												R		R									R	R									R
DIAG SOURCE10																											R	R											
DIAG SOURCE5																											R	R											
DIAG SOURCE2																											R	R											
DIAG DIFFAMP																											R	R											
DIAG DIVIDER1																											R	R											
DIAG DIVIDER2																											R	R											
DIAG 10K CAL																				R							R	R											
DIAG 19K CAL																				R								R	R										R
DIAG CHK 10K	R														R			R		R							R												
DIAG CHK 19K	R																	R		R										R						R			R
DIAG CHK 1K	R														R						R	R					R												
DIAG CHK 1.9K	R																				R	R								R						R			R
DIAG CHK 100	R														R								R	R			R												
DIAG CHK 190	R																						R	R						R						R			R
DIAG CHK 10	R														R										R	R	R												
DIAG CHK 19	R																								R	R				R						R			R
DIAG 10 CAL																							R			R	R				R	R	R						
DIAG 19 CAL																							R			R				R	R			R					R
DIAG RATIO 100K																		R	R								R	R					R						
DIAG RATIO 190K																		R	R									R		R				R					R
DIAG RATIO 1M			R							R					R	R	R										R	R					R				R		
DIAG RATIO 1.9M			R											R			R											R						R	R	R	R		R
DIAG RATIO 10M			R					■	R						R												R	R					R						
DIAG RATIO 19M1			R									■	R															R						R		R			R
DIAG RATIO 19M2			R								■	■																R						R		R			R
DIAG RATIO 100M	R		R		■		R								R												R	R					R						
DIAG CHK 1	R														R																								
DIAG CHK 1.9	R														R																								
DIAG CHK SHORT	R														R																								
DIAG 2W COMP	R			R		■							R	R											R	R	R												

OHMS CAL ASSEMBLY RELAYS AND FETS

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20	K21	K22	K23	K24	K25	K26	K27	K28	K29	K30	K31	Q2	Q3	Q4	Q6
INIT AND STANDBY											R				R			R																	
4 WIRE SHORT							R	R			R				R			R				R		R	R										
4 WIRE 1 OHM				R	R	R					R				R			R				R		R	R										
4 WIRE 1.9 OHM				R	R						R				R			R				R		R	R					R					
4 WIRE 10 OHM											R				R			R				R		R	R										
4 WIRE 19 OHM											R				R			R				R		R	R										
4 WIRE 100 OHM											R				R			R				R		R	R										
4 WIRE 190 OHM											R				R			R				R		R	R										
4 WIRE 1K OHM											R				R			R				R		R	R										
4 WIRE 1.9K OHM											R				R			R				R		R	R										
4 WIRE 10K OHM											R				R			R				R		R	R										
4 WIRE 19K OHM											R				R			R				R		R	R										
4 WIRE 100K OHM											R				R			R				R		R	R										
4 WIRE 190K OHM											R				R			R				R		R	R										
4 WIRE 1M OHM											R				R			R				R		R	R										
4 WIRE 1.9M OHM											R				R			R				R		R	R										
4 WIRE 10M OHM											R				R			R				R		R	R										
4 WIRE 19M OHM											R				R			R				R		R	R										
2 WIRE 100M OHM											R				R			R				R		R											
2 WIRE COMP. SHORT							R	R			R				R			R						R				R	R						■
2 WIRE COMP. 1 OHM				R	R	R					R				R			R						R				R	R						■
2 WIRE COMP. 1.9 OHM				R	R						R				R			R						R				R	R	R					■
2 WIRE COMP. 10 OHM											R				R			R						R				R	R						■
2 WIRE COMP. 19 OHM											R				R			R						R				R	R						■
2 WIRE COMP. 100 OHM											R				R			R						R				R	R						■
2 WIRE COMP. 190 OHM											R				R			R						R				R	R						■
2 WIRE COMP. 1K OHM											R				R			R						R				R	R						■
2 WIRE COMP. 1.9K OHM											R				R			R						R				R	R						■
2 WIRE COMP. 10K OHM											R				R			R						R				R	R						■
2 WIRE COMP. 19K OHM											R				R			R						R				R	R						■
DIAG SOURCE10									R	R	R	R										R	R				R				R				
DIAG SOURCE5									R	R	R	R										R	R				R				R	■			
DIAG SOURCE2									R	R	R	R										R	R				R				R	■	■		
DIAG DIFFAMP									R	R		R					R	R		R	R	R					R								
DIAG DIVIDER1									R	R		R				R		R		R	R	R					R								
DIAG DIVIDER2									R	R		R			R			R		R	R	R					R								
DIAG 10K CAL									R	R		R					R		R			R	R				R				R				
DIAG 19K CAL									R	R		R					R		R			R	R				R				R				
DIAG CHK 10K	R									R		R										R	R				R				R				
DIAG CHK 19K	R									R		R										R	R				R				R				
DIAG CHK 1K	R									R		R										R	R				R				R				
DIAG CHK 1.9K	R									R		R										R	R				R				R				
DIAG CHK 100	R									R		R										R	R				R				R				
DIAG CHK 190	R									R		R										R	R				R				R				
DIAG CHK 10	R									R		R										R	R				R				R				
DIAG CHK 19	R									R		R										R	R				R				R				
DIAG 10 CAL		R							R	R				R		R				R	R	R					R					■	■		
DIAG 19 CAL		R							R	R				R		R				R	R	R					R					■	■		
DIAG RATIO 100K	R								R	R		R										R	R				R				R				
DIAG RATIO 190K	R								R	R		R										R	R				R				R				
DIAG RATIO 1M			R						R	R		R										R	R				R				R				
DIAG RATIO 1.9M			R						R	R		R										R	R				R				R				
DIAG RATIO 10M			R						R	R		R										R	R				R				R				
DIAG RATIO 19M1			R						R	R		R										R	R				R				R				
DIAG RATIO 19M2			R						R	R		R										R	R				R				R				
DIAG RATIO 100M			R						R	R		R										R	R				R				R				
DIAG CHK 1	R			R	R	R				R												R					R				R			■	
DIAG CHK 1.9	R			R	R					R												R					R			R	R			■	
DIAG CHK SHORT	R						R	R		R												R					R				R			■	
DIAG 2W COMP																						R						R	R						■

R = RESET POSITION FOR LATCHING RELAYS
■ = ENERGIZED POSITION FOR NON LATCHING RELAYS
NOTE: RELAYS SHOWN IN THE SET POSITION ON THE SCHEMATICS

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Figure 7-10. A10 Ohms Main PCA (cont)

OHMS MAIN ASSEMBLY RELAYS

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20	K21	K22	K23	K24	K25	K26	K27	K28	K29	K30	K31	K32	K33	K34	K35	K36	K37	K38	K39
10K OHM COMMON MODE MEASUREMENT																											R												
10K BIAS CURRENT MEASUREMENT 1ST																											R												
2ND																											R												
CAL INT 10K STD FROM EXT 10K STD 1ST	R														R													R											
2ND	R														R													R											
3RD	R	R													R	R												R											
CAL 10K FROM INT 10K STD 1ST																				R							R	R											
2ND																				R							R	R											
3RD																		R		R							R	R											
CAL 19K FROM INT 10K STD 1ST																				R								R	R	R									R
2ND																				R								R	R	R									R
3RD																		R		R								R	R	R									R
RATIO CAL 100K FROM 10K 1ST																	R		R								R	R					R				R		
2ND																		R	R								R	R					R						
RATIO CAL 190K FROM 19K 1ST																	R		R									R		R				R			R		R
2ND																		R	R									R		R				R					R
1M OHM COMMON MODE MEASUREMENT			R													R											R												
RATIO CAL 1M FROM 100K 1ST			R						R	R					R												R	R					R						
2ND			R							R					R	R	R										R	R					R				R		
RATIO CAL 1.9M FROM 190K 1ST			R										R	R														R						R		R			R
2ND			R											R			R											R						R	R	R	R		R
RATIO CAL 10M FROM 1M 1ST			R				R	■							R												R	R					R						
2ND			R					■	R						R												R	R					R						
RATIO CAL 19M FROM 1.9M 1ST			R								■	■																R						R		R			R
2ND			R									■	R															R						R		R			R
100M BIAS CURRENT MEASUREMENT 1ST			R													R		R									R												
2ND			R				R																				R												
RATIO CAL 100M FROM 10M	R		R		■		R								R												R	R					R						
RATIO CAL 1K FROM 10K 1ST																		R		R							R	R					R						
2ND																				R		R					R	R					R						
RATIO CAL 1.9K FROM 19K 1ST																		R		R								R		R				R					R
2ND																				R		R						R		R				R					R
CAL INT DIVIDER 1ST																											R	R											
2ND																											R	R											
100 OHM BIAS MEASUREMENT 1ST																											R												
2ND																								R			R												
RATIO CAL 100 OHM FROM 1K 1ST																					R	R					R	R			R	R	R						
2ND																					R			R			R	R			R	R	R						
190 OHM BIAS MEASUREMENT 1ST																																							R
2ND																								R						R									R
RATIO CAL 190 OHM FROM 1.9K 1ST																					R	R						R		R	R			R					R
2ND																					R			R				R		R	R			R					R
10 OHM BIAS MEASUREMENT 1ST																											R												
2ND																										R	R												
RATIO CAL 10 OHM FROM 100 OHM 1ST																							R	R			R	R			R	R	R						
2ND																							R			R	R	R			R	R	R						
19 OHM BIAS MEASUREMENT 1ST																																							R
2ND																										R				R									R
RATIO CAL 19 OHM FROM 190 OHM 1ST																							R	R				R		R	R			R					R
2ND																							R			R		R		R	R			R					R
1 OHM COMMON MODE MEASUREMENT 1ST		R														R																							
CAL 1 OHM FROM EXT 1 OHM STD 1ST		R														R																							
1 OHM COMMON MODE MEASUREMENT 2ND																																							
CAL 1 OHM FROM EXT 1 OHM STD 2ND																																							
1.9 OHM COMMON MODE MEASUREMENT 1ST		R														R																							
CAL 1.9 OHM FROM EXT 1 OHM STD 1ST		R														R																							
1.9 OHM COMMON MODE MEASUREMENT 2ND																																							
CAL 1.9 OHM FROM EXT 1 OHM STD 2ND																																							
5725A AMP ZERO	R		R												R	R									R	R	R												

OHMS CAL ASSEMBLY RELAYS AND FETS

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20	K21	K22	K23	K24	K25	K26	K27	K28	K29	K30	K31	Q2	Q3	Q4	Q6
10K OHM COMMON MODE MEASUREMENT										R	R	R										R	R				R				R				
10K BIAS CURRENT MEASUREMENT 1ST										R							R			R	R	R					R							■	
2ND										R						R				R	R	R					R							■	
CAL INT 10K STD FROM EXT 10K STD 1ST									R	R		R				R			R			R	R	R	R		R				R				
2ND									R	R		R					R		R			R	R	R	R		R				R				
3RD	R								R	R		R							R			R	R	R	R		R				R				
CAL 10K FROM INT 10K STD 1ST									R	R		R				R			R			R	R				R				R				
2ND									R	R		R					R		R			R	R				R				R				
3RD	R								R	R		R							R			R	R				R				R				
CAL 19K FROM INT 10K STD 1ST									R	R		R				R			R			R	R				R				R				
2ND									R	R		R					R		R			R	R				R				R				
3RD	R								R	R		R							R			R	R				R				R				
RATIO CAL 100K FROM 10K 1ST	R								R	R		R										R	R				R				R				
2ND	R								R	R		R										R	R				R				R				
RATIO CAL 190K FROM 19K 1ST	R								R	R		R										R	R				R				R				
2ND	R								R	R		R										R	R				R				R				
1M OHM COMMON MODE MEASUREMENT		R	R							R		R										R	R				R				R				
RATIO CAL 1M FROM 100K 1ST			R						R	R		R										R	R				R				R				
2ND			R						R	R		R										R	R				R				R				
RATIO CAL 1.9M FROM 190K 1ST			R						R	R		R										R	R				R				R				
2ND			R						R	R		R										R	R				R				R				
RATIO CAL 10M FROM 1M 1ST			R						R	R		R										R	R				R				R				
2ND			R						R	R		R										R	R				R				R				
RATIO CAL 19M FROM 1.9M 1ST			R						R	R		R										R	R				R				R				
2ND			R						R	R		R										R	R				R				R				
100M BIAS CURRENT MEASUREMENT 1ST			R							R												R	R				R				R			■	
2ND			R							R												R	R				R				R			■	
RATIO CAL 100M FROM 10M			R						R	R		R										R	R				R				R				
RATIO CAL 1K FROM 10K 1ST	R								R	R		R										R	R				R				R				
2ND	R								R	R		R										R	R				R				R				
RATIO CAL 1.9K FROM 19K 1ST	R								R	R		R										R	R				R				R				
2ND	R								R	R		R										R	R				R				R				
CAL INT DIVIDER 1ST									R	R		R			R			R		R	R	R					R								
2ND									R	R		R				R		R		R	R	R					R								
100 OHM BIAS MEASUREMENT 1ST											R						R			R	R	R					R								
2ND		R																		R	R	R					R								
RATIO CAL 100 OHM FROM 1K 1ST		R							R	R				R	R					R	R	R					R					■	■		
2ND		R							R	R				R		R				R	R	R					R					■	■		
190 OHM BIAS MEASUREMENT 1ST											R						R			R	R	R					R								
2ND		R																		R	R	R					R								
RATIO CAL 190 OHM FROM 1.9K 1ST																	R			R	R	R					R					■	■		
2ND		R									R									R	R	R					R					■	■		
10 OHM BIAS MEASUREMENT 1ST											R						R			R	R	R					R								
2ND		R																		R	R	R					R								
RATIO CAL 10 OHM FROM 100 OHM 1ST		R							R	R				R	R					R	R	R					R					✱	✱		
2ND		R							R	R				R		R				R	R	R					R					✱	✱		
19 OHM BIAS MEASUREMENT 1ST											R						R			R	R	R					R								
2ND		R																		R	R	R					R								
RATIO CAL 19 OHM FROM 190 OHM 1ST		R							R	R				R	R					R	R	R					R					■	■		
2ND		R							R	R				R		R				R	R	R					R					■	■		
1 OHM COMMON MODE MEASUREMENT 1ST	R					R				R	R											R				R	R				R				
CAL 1 OHM FROM EXT 1 OHM STD 1ST	R					R				R			R									R				R	R				R				
1 OHM COMMON MODE MEASUREMENT 2ND	R			R		R				R	R											R				R	R				R				
CAL 1 OHM FROM EXT 1 OHM STD 2ND	R			R		R				R												R				R	R				R			■	
1.9 OHM COMMON MODE MEASUREMENT 1ST	R									R	R											R				R	R			R	R				
CAL 1.9 OHM FROM EXT 1 OHM STD 1ST	R									R			R									R				R	R			R	R				
1.9 OHM COMMON MODE MEASUREMENT 2ND	R			R						R	R											R				R	R			R	R				
CAL 1.9 OHM FROM EXT 1 OHM STD 2ND	R			R						R												R				R	R			R	R			■	
5725A AMP ZERO			R																			R					R				R			■	

R = RESET POSITION FOR LATCHING RELAYS
■ = ENERGIZED POSITION FOR NON LATCHING RELAYS AND ON FOR FETS
NOTE: RELAYS SHOWN IN THE SET POSITION ON THE SCHEMATICS

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Figure 7-10. A10 Ohms Main PCA (cont)

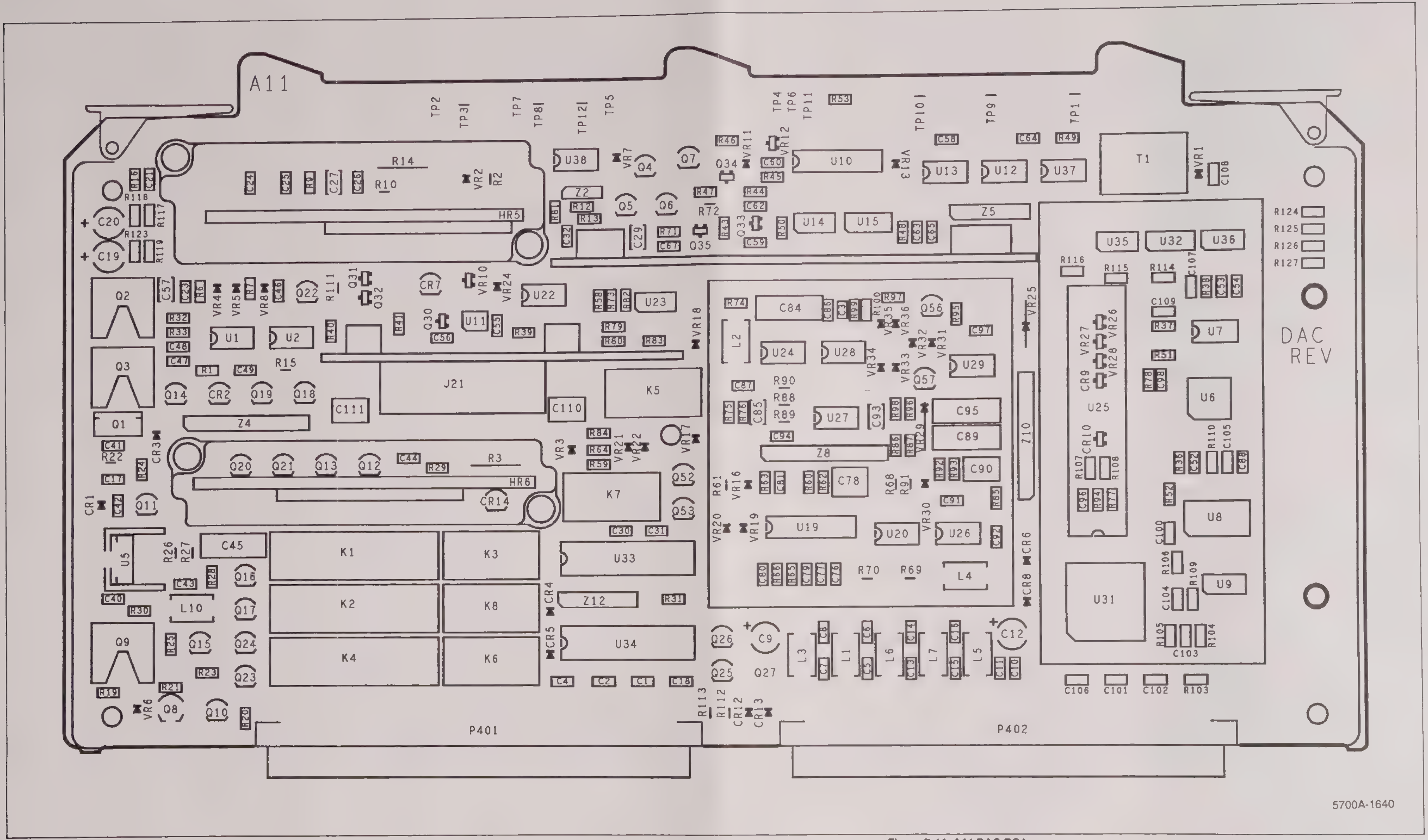
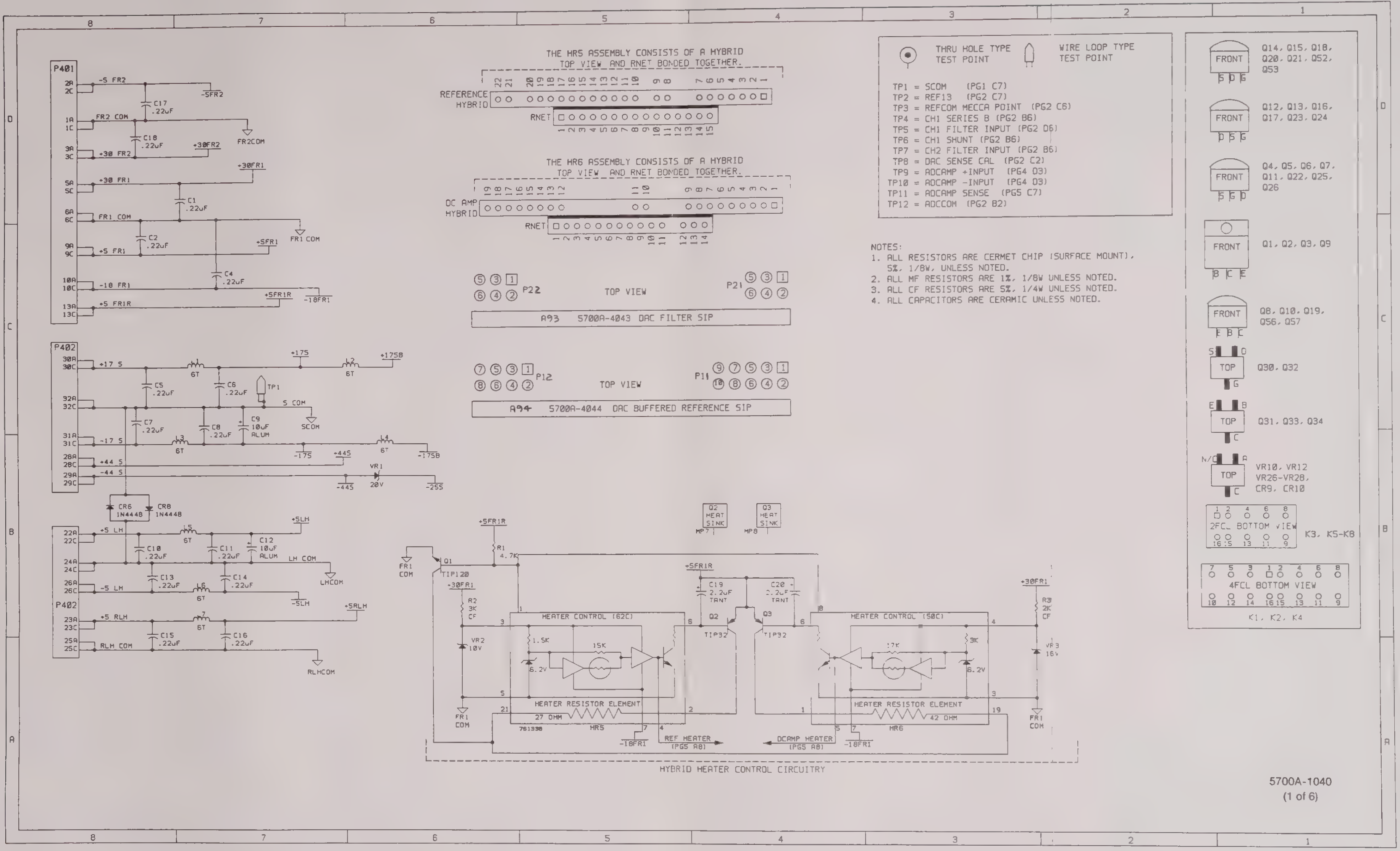


Figure 7-11. A11 DAC PCA



THRU HOLE TYPE TEST POINT
WIRE LOOP TYPE TEST POINT
THE HR5 ASSEMBLY CONSISTS OF A HYBRID TOP VIEW AND RNET BONDED TOGETHER.
REFERENCE HYBRID
RNET
THE HR6 ASSEMBLY CONSISTS OF A HYBRID TOP VIEW AND RNET BONDED TOGETHER.
DC AMP HYBRID
P22
P21
TOP VIEW
A93 5700A-4043 DAC FILTER SIP
P12
P11
A94 5700A-4044 DAC BUFFERED REFERENCE SIP
P401
P402
HYBRID HEATER CONTROL CIRCUITRY
HEATER CONTROL (62C)
HEATER CONTROL (58C)
HEATER RESISTOR ELEMENT
27 OHM
42 OHM
HR5
HR6
REF HEATER (PG5 A8)
DCAMP HEATER (PG5 A8)
Q1 TIP120
Q2 TIP32
Q3 TIP32
Q2 HEAT SINK MP7
Q3 HEAT SINK MP8
CR6 1N4448
CR8 1N4448
Q14, Q15, Q18, Q20, Q21, Q52, Q53
Q12, Q13, Q16, Q17, Q23, Q24
Q4, Q5, Q6, Q7, Q11, Q22, Q25, Q26
Q1, Q2, Q3, Q9
Q8, Q10, Q19, Q56, Q57
Q30, Q32
Q31, Q33, Q34
VR10, VR12 VR26-VR28, CR9, CR10
2FCL BOTTOM VIEW
K3, K5-K8
4FCL BOTTOM VIEW
K1, K2, K4
FRONT
TOP
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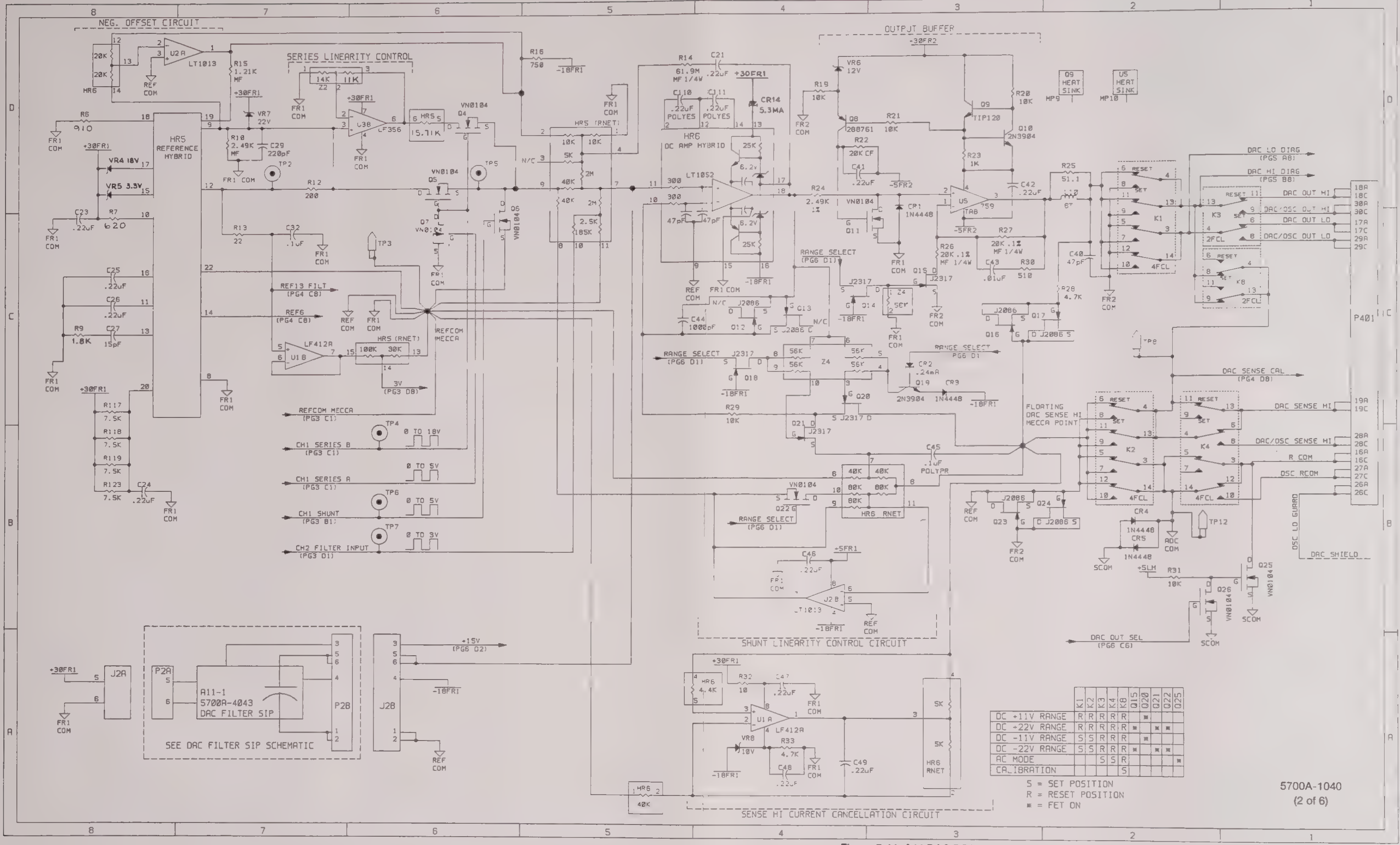
TP1 = SCOM (PG1 C7)
TP2 = REF13 (PG2 C7)
TP3 = REFCOM MECCA POINT (PG2 C6)
TP4 = CH1 SERIES B (PG2 B6)
TP5 = CH1 FILTER INPUT (PG2 D6)
TP6 = CH1 SHUNT (PG2 B6)
TP7 = CH2 FILTER INPUT (PG2 B6)
TP8 = DAC SENSE CAL (PG2 C2)
TP9 = ADCAMP +INPUT (PG4 D3)
TP10 = ADCAMP -INPUT (PG4 D3)
TP11 = ADCAMP SENSE (PG5 C7)
TP12 = ADCCOM (PG2 B2)

NOTES:

1. ALL RESISTORS ARE CERMET CHIP (SURFACE MOUNT), 5%, 1/8W, UNLESS NOTED.
2. ALL MF RESISTORS ARE 1%, 1/8W UNLESS NOTED.
3. ALL CF RESISTORS ARE 5%, 1/4W UNLESS NOTED.
4. ALL CAPACITORS ARE CERAMIC UNLESS NOTED.

Figure 7-11. A11 DAC PCA (cont)



	K1	K2	K3	K4	K8	Q15	Q20	Q21	Q22	Q25
DC +11V RANGE	R	R	R	R	R		■			
DC +22V RANGE	R	R	R	R	R	■		■	■	
DC -11V RANGE	S	S	R	R	R		■			
DC -22V RANGE	S	S	R	R	R	■		■	■	
AC MODE			S	S	R					■
CALIBRATION					S					

S = SET POSITION
R = RESET POSITION
■ = FET ON

Figure 7-11. A11 DAC PCA (cont)

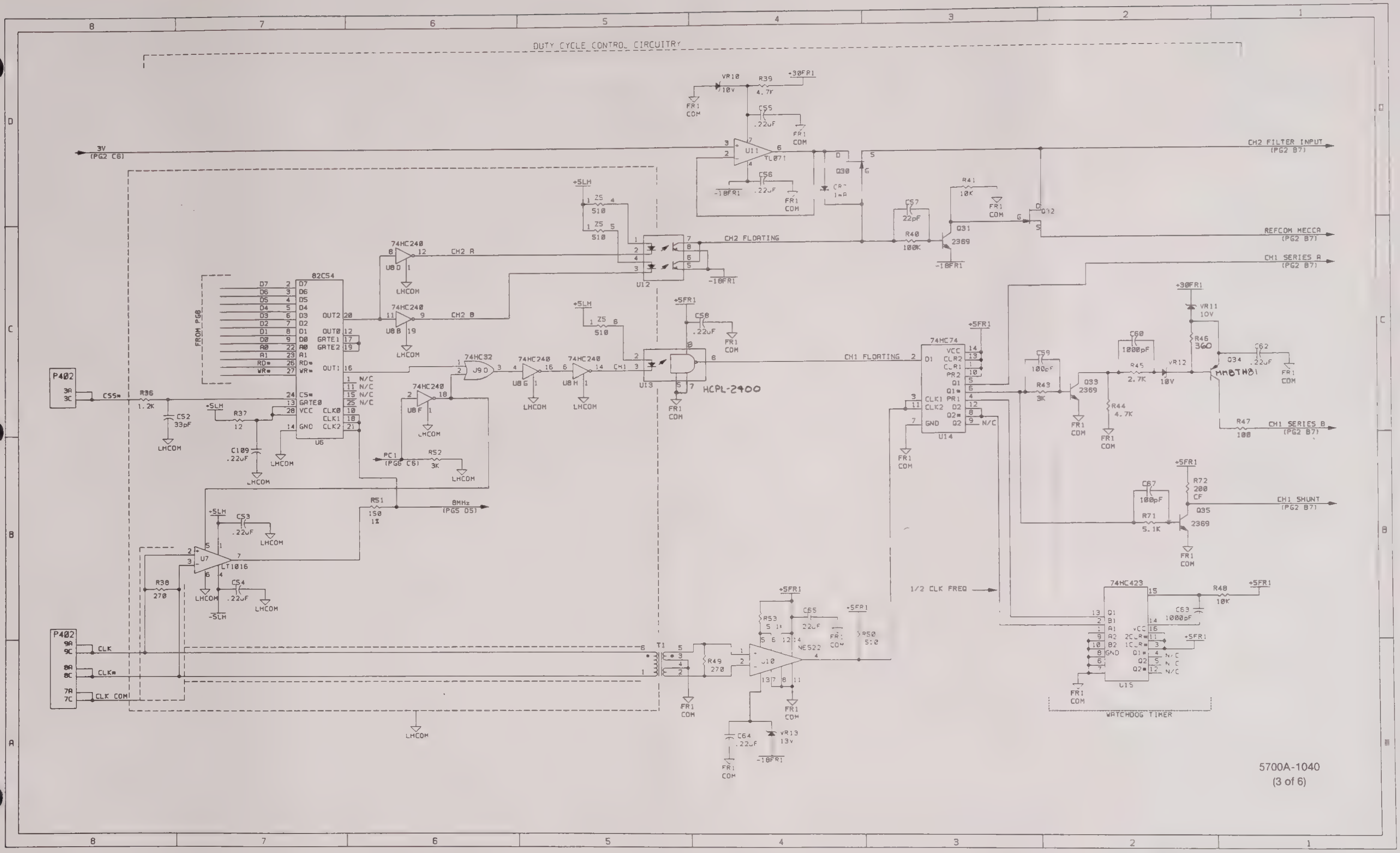


Figure 7-11. A11 DAC PCA (cont)

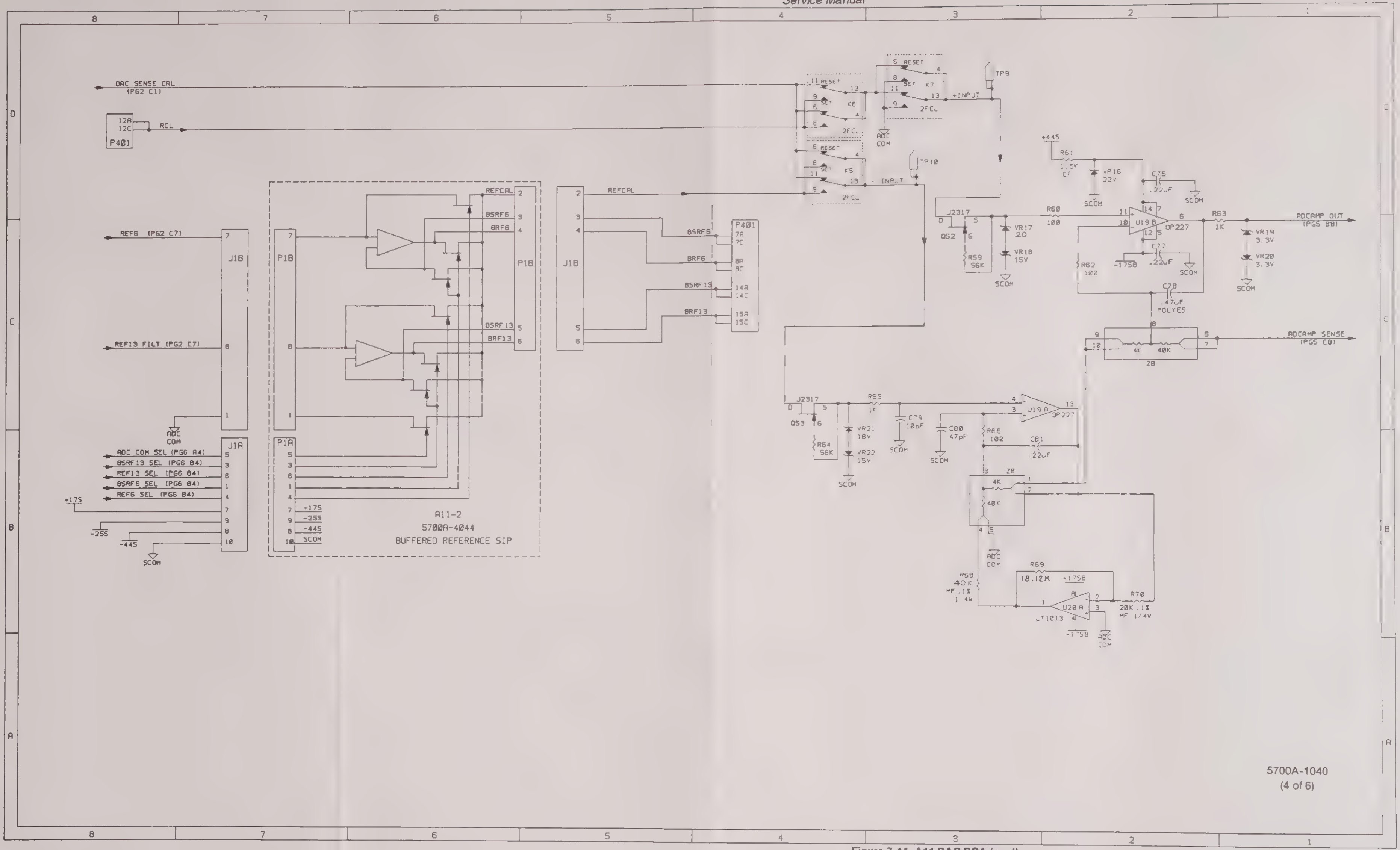


Figure 7-11. A11 DAC PCA (cont)

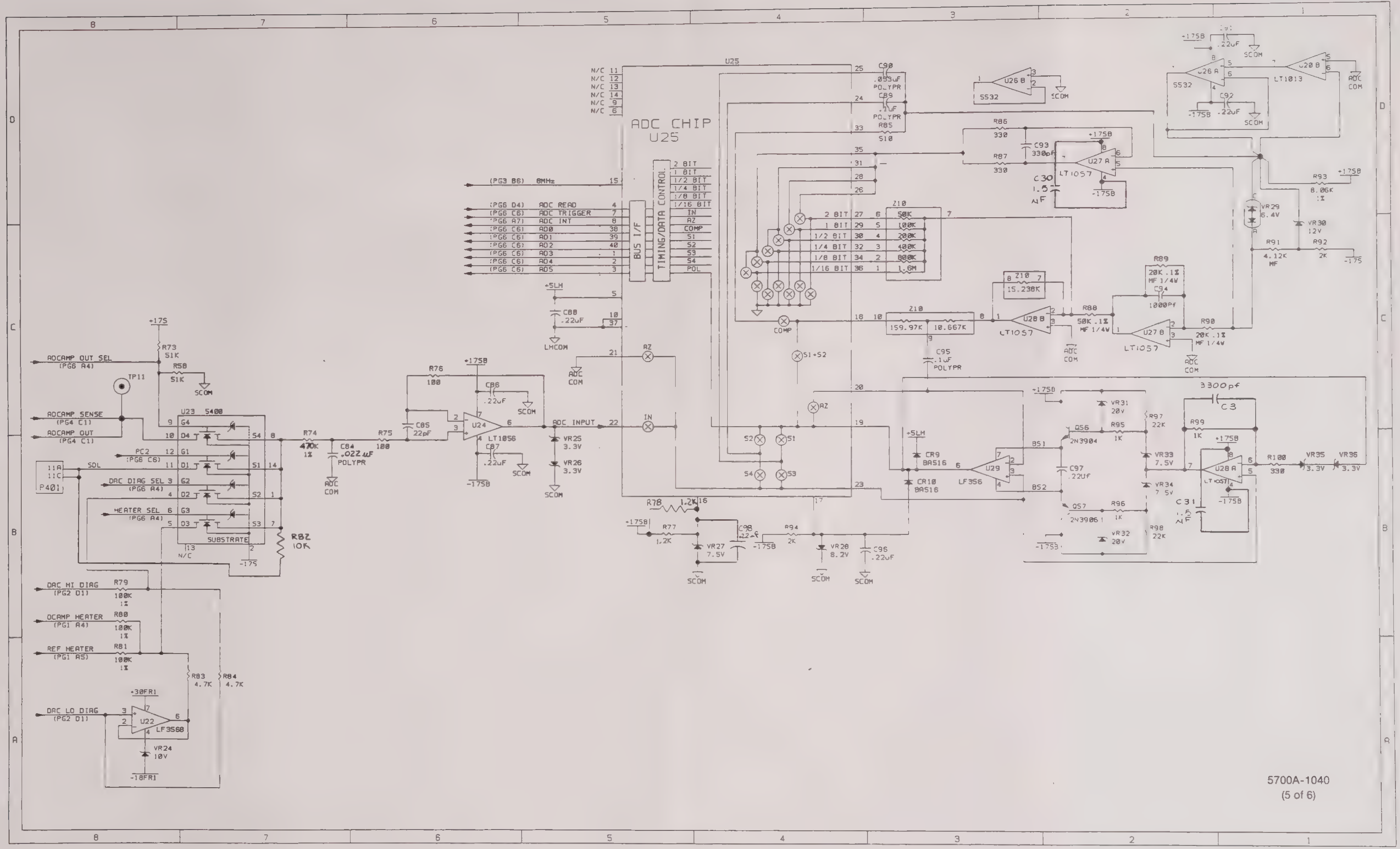


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Figure 7-11. A11 DAC PCA (cont)

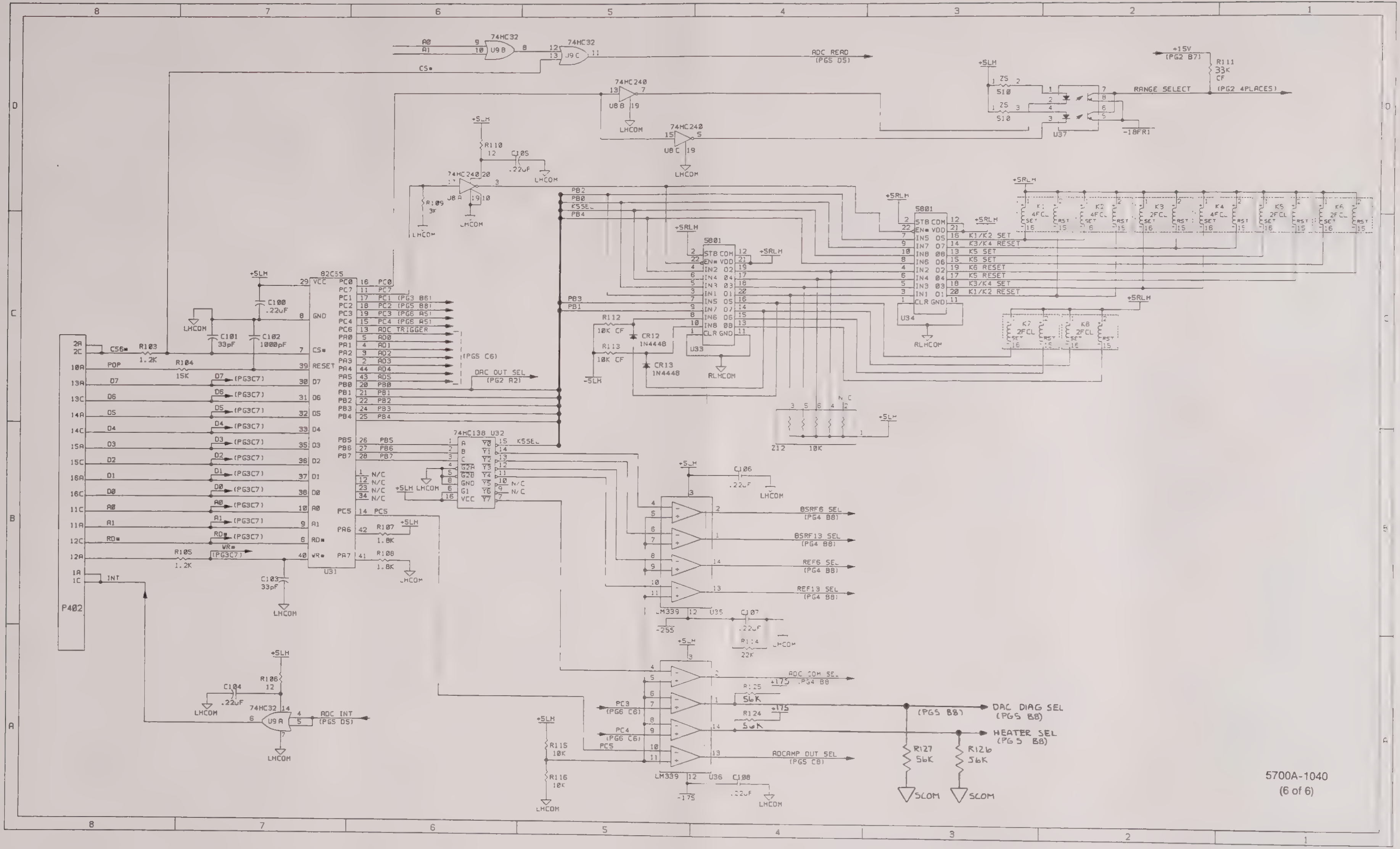
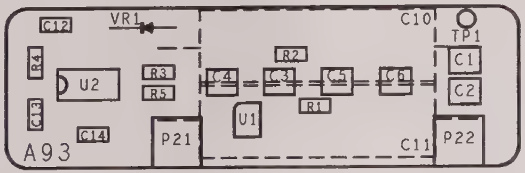
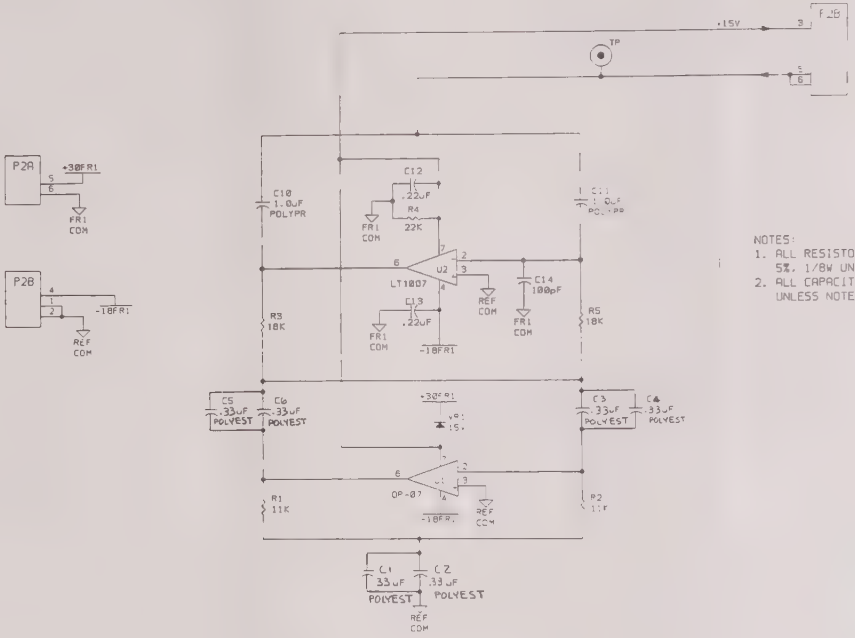


Figure 7-11. A11 DAC PCA (cont)



5700A-1643



NOTES:
1. ALL RESISTORS ARE CERMET CHIP (SURFACE MOUNT), 5%, 1/8W UNLESS NOTED.
2. ALL CAPACITORS ARE CERAMIC (SURFACE MOUNT), UNLESS NOTED.

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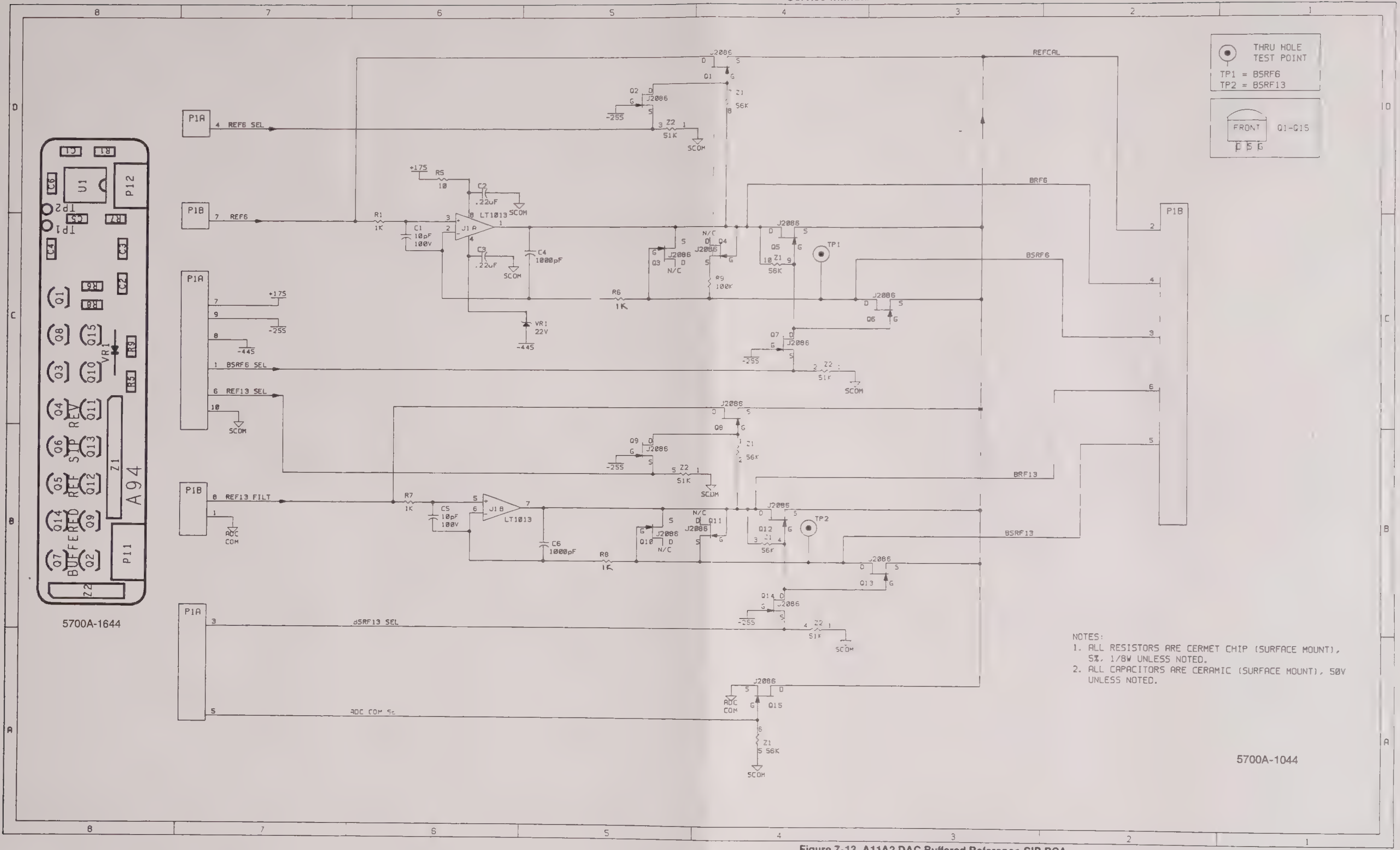
Figure 7-12. A11A1 DAC Filter SIP PCA



NOTES:
1. ALL RESISTORS ARE CERMET CHIP (SURFACE MOUNT), 5%, 1/8W UNLESS NOTED.
2. ALL CAPACITORS ARE CERAMIC (SURFACE MOUNT), 50V UNLESS NOTED.

Figure 7-13. A11A2 DAC Buffered Reference SIP PCA

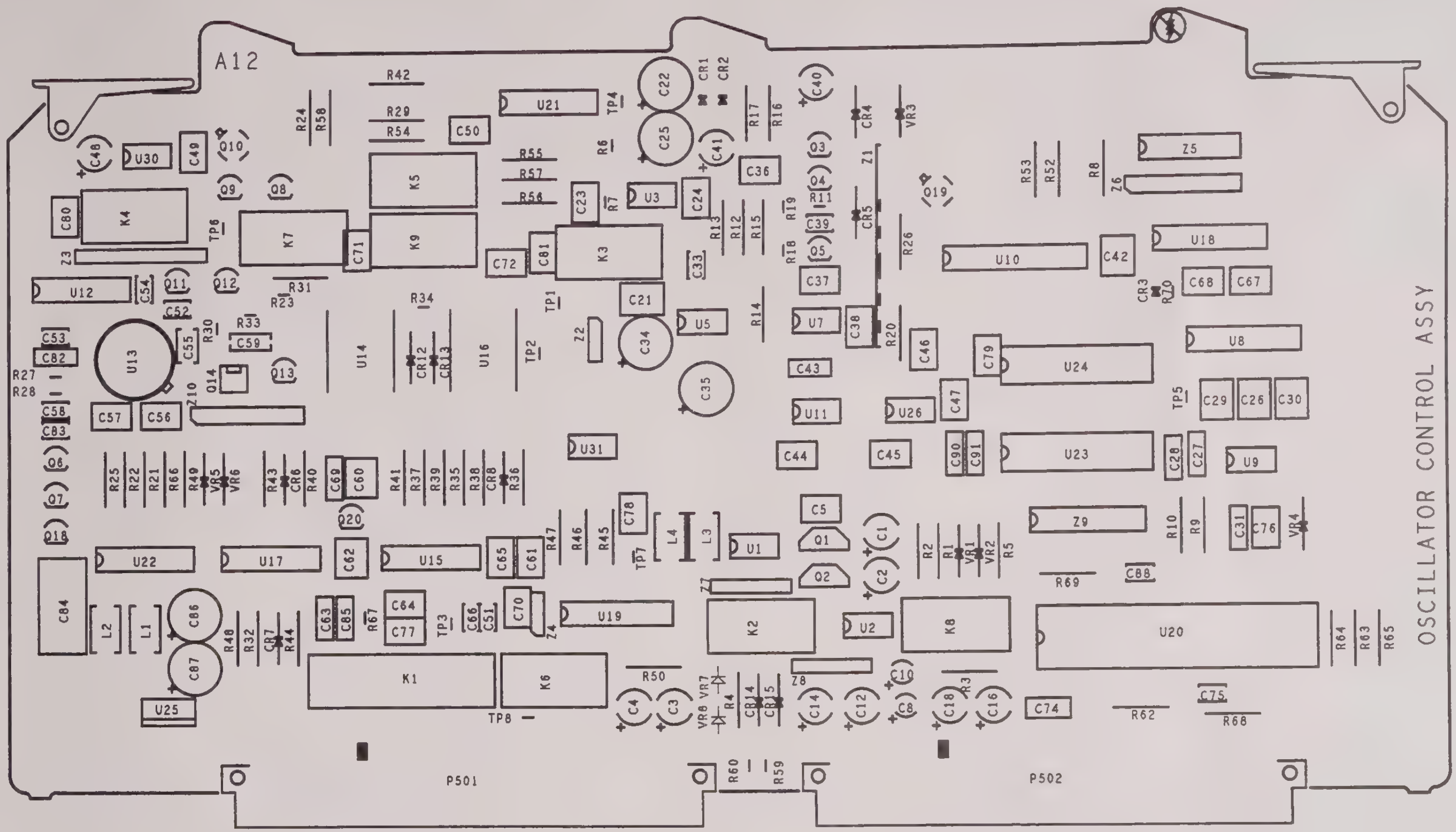
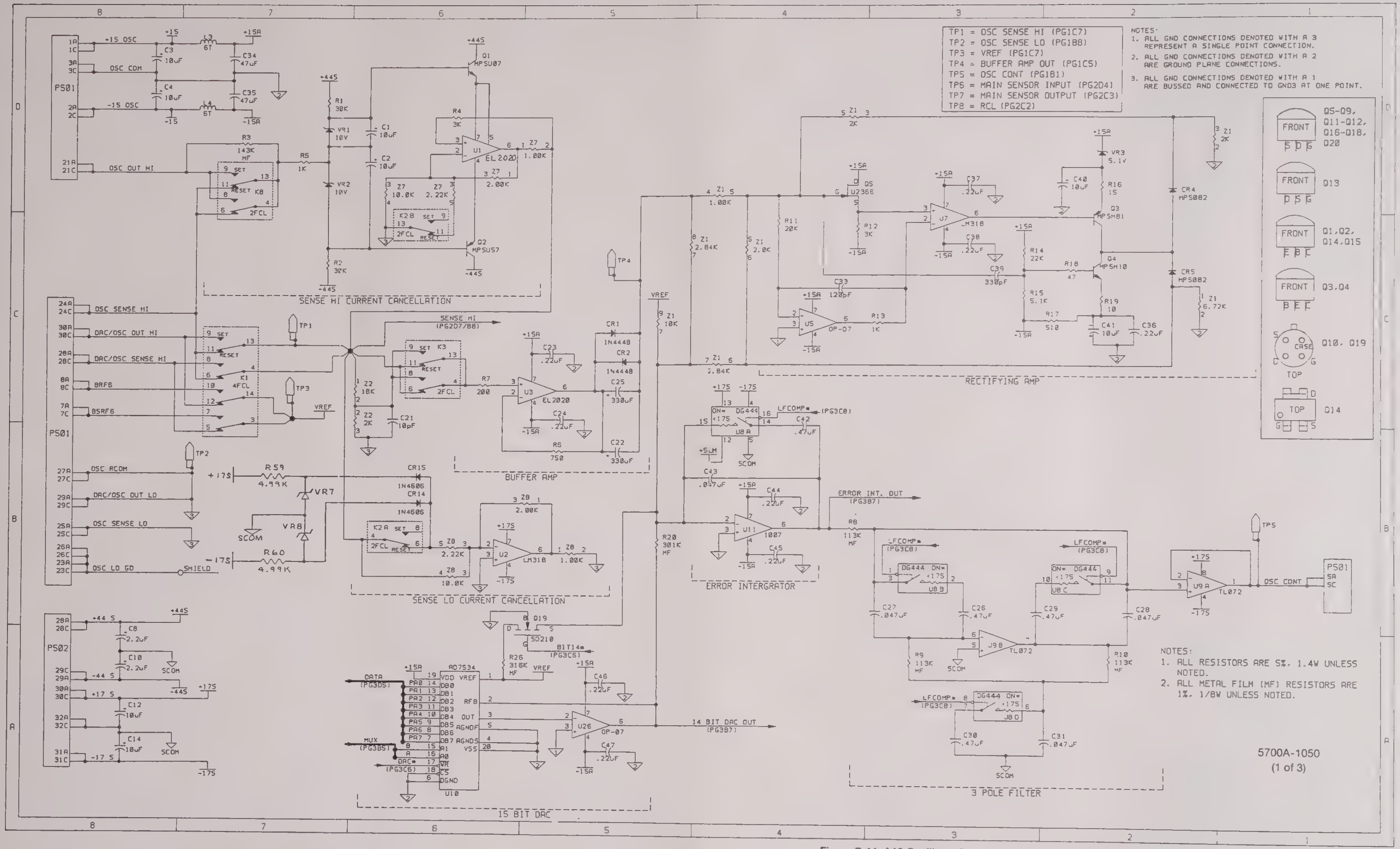


Figure 7-14. A12 Oscillator Control PCA (cont)



TP1 = OSC SENSE HI (PG1C7)
TP2 = OSC SENSE LO (PG1B8)
TP3 = VREF (PG1C7)
TP4 = BUFFER AMP OUT (PG1C5)
TP5 = OSC CONT (PG1B1)
TP6 = MAIN SENSOR INPUT (PG2D4)
TP7 = MAIN SENSOR OUTPUT (PG2C3)
TP8 = RCL (PG2C2)

NOTES:
1. ALL GND CONNECTIONS DENOTED WITH A 3 REPRESENT A SINGLE POINT CONNECTION.
2. ALL GND CONNECTIONS DENOTED WITH A 2 ARE GROUND PLANE CONNECTIONS.
3. ALL GND CONNECTIONS DENOTED WITH A 1 ARE BUSSED AND CONNECTED TO GND3 AT ONE POINT.

NOTES:
1. ALL RESISTORS ARE 5%, 1.4W UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.

Figure 7-14. A12 Oscillator Control PCA (cont)

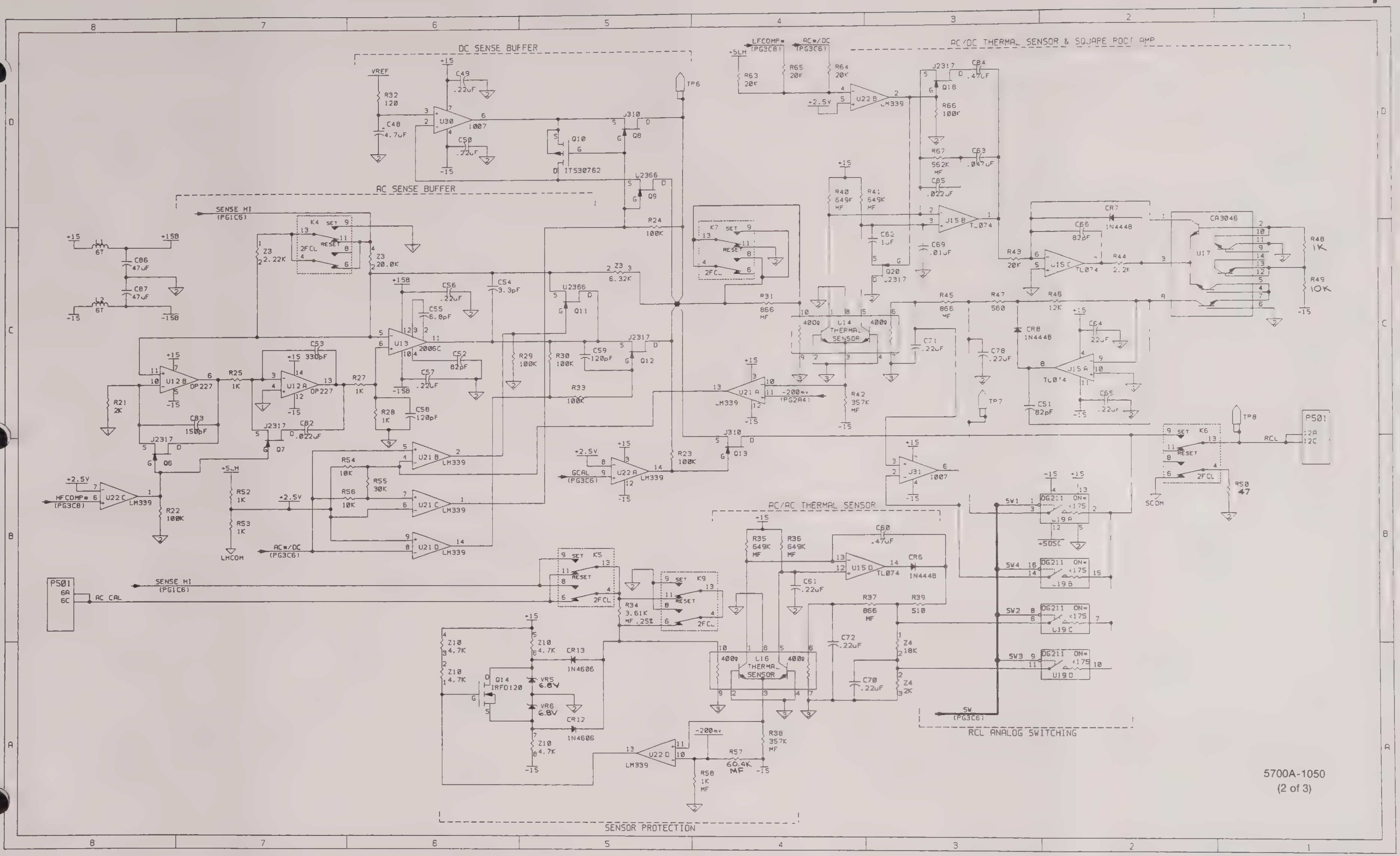
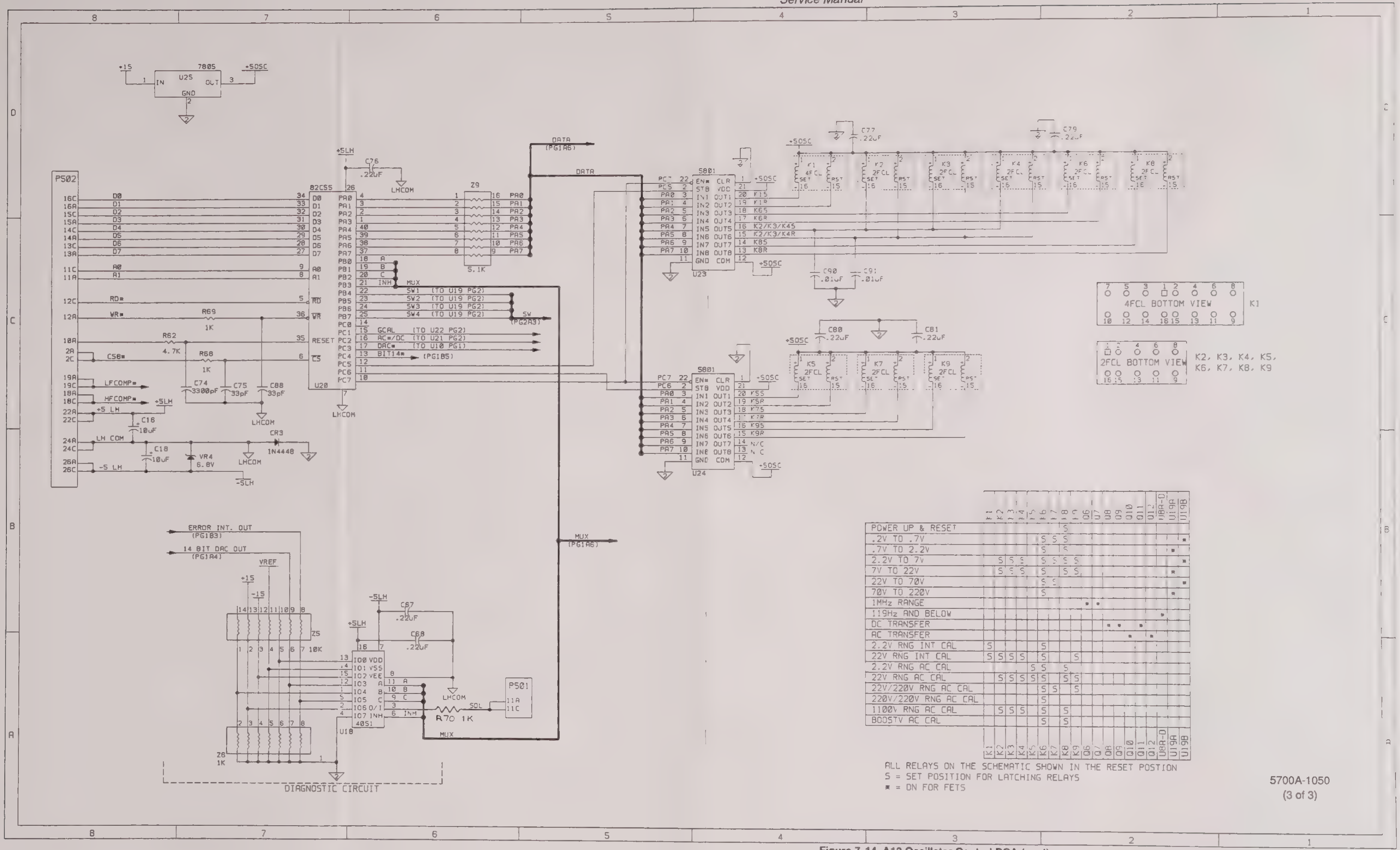


Figure 7-14. A12 Oscillator Control PCA (cont)



	K1	K2	K3	K4	K5	K6	K7	K8	K9	Q6	Q7	Q8	Q9	Q10	Q11	Q12	U8A-D	U19A	U19B
POWER UP & RESET								S											
.2V TO .7V						S	S	S											■
.7V TO 2.2V						S		S										■	
2.2V TO 7V		S	S	S		S	S	S	S										■
7V TO 22V		S	S	S		S		S	S									■	
22V TO 70V						S	S												■
70V TO 220V						S												■	
1MHz RANGE										■	■								
119Hz AND BELOW																	■		
DC TRANSFER												■	■		■				
AC TRANSFER														■		■			
2.2V RNG INT CAL	S					S													
22V RNG INT CAL	S	S	S	S		S			S										
2.2V RNG AC CAL					S	S		S											
22V RNG AC CAL		S	S	S	S	S		S	S										
22V/220V RNG AC CAL						S	S		S										
220V/220V RNG AC CAL						S													
1100V RNG AC CAL		S	S	S		S		S											
BOOSTV AC CAL						S		S											

ALL RELAYS ON THE SCHEMATIC SHOWN IN THE RESET POSTION
S = SET POSITION FOR LATCHING RELAYS
■ = ON FOR FETS

Figure 7-14. A12 Oscillator Control PCA (cont)

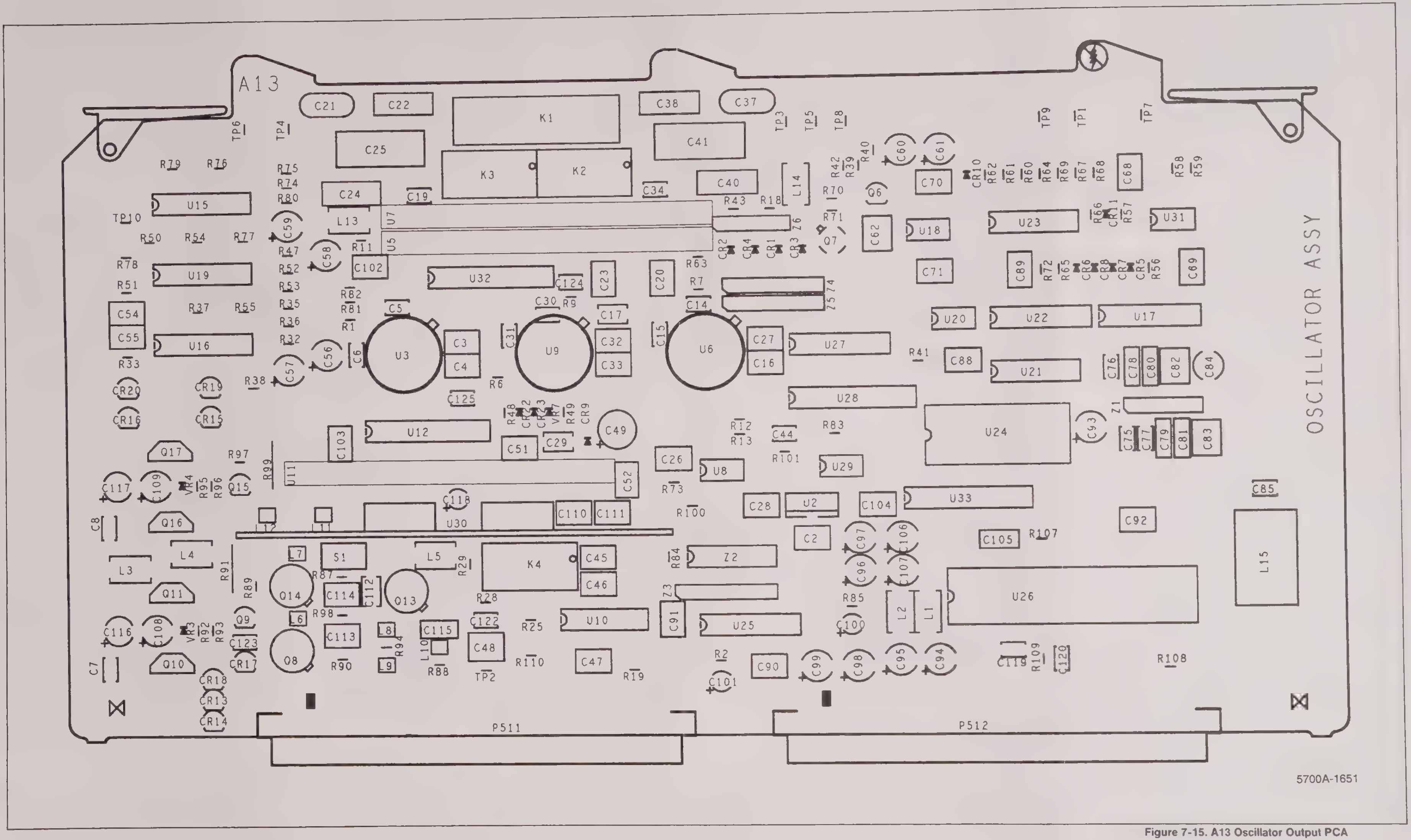
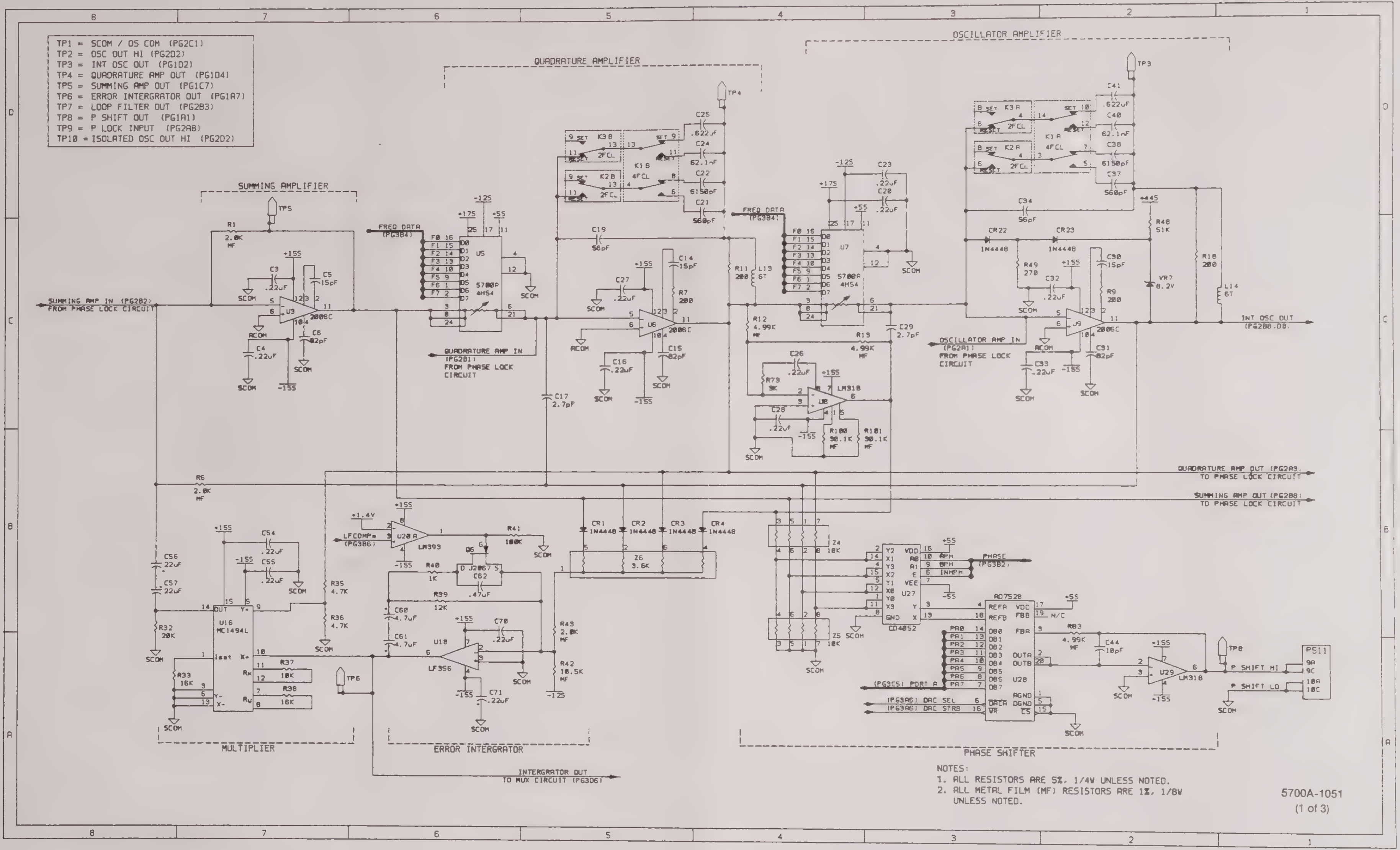


Figure 7-15. A13 Oscillator Output PCA



NOTES:
1. ALL RESISTORS ARE 5%, 1/4W UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.

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Figure 7-15. A13 Oscillator Output PCA (cont)

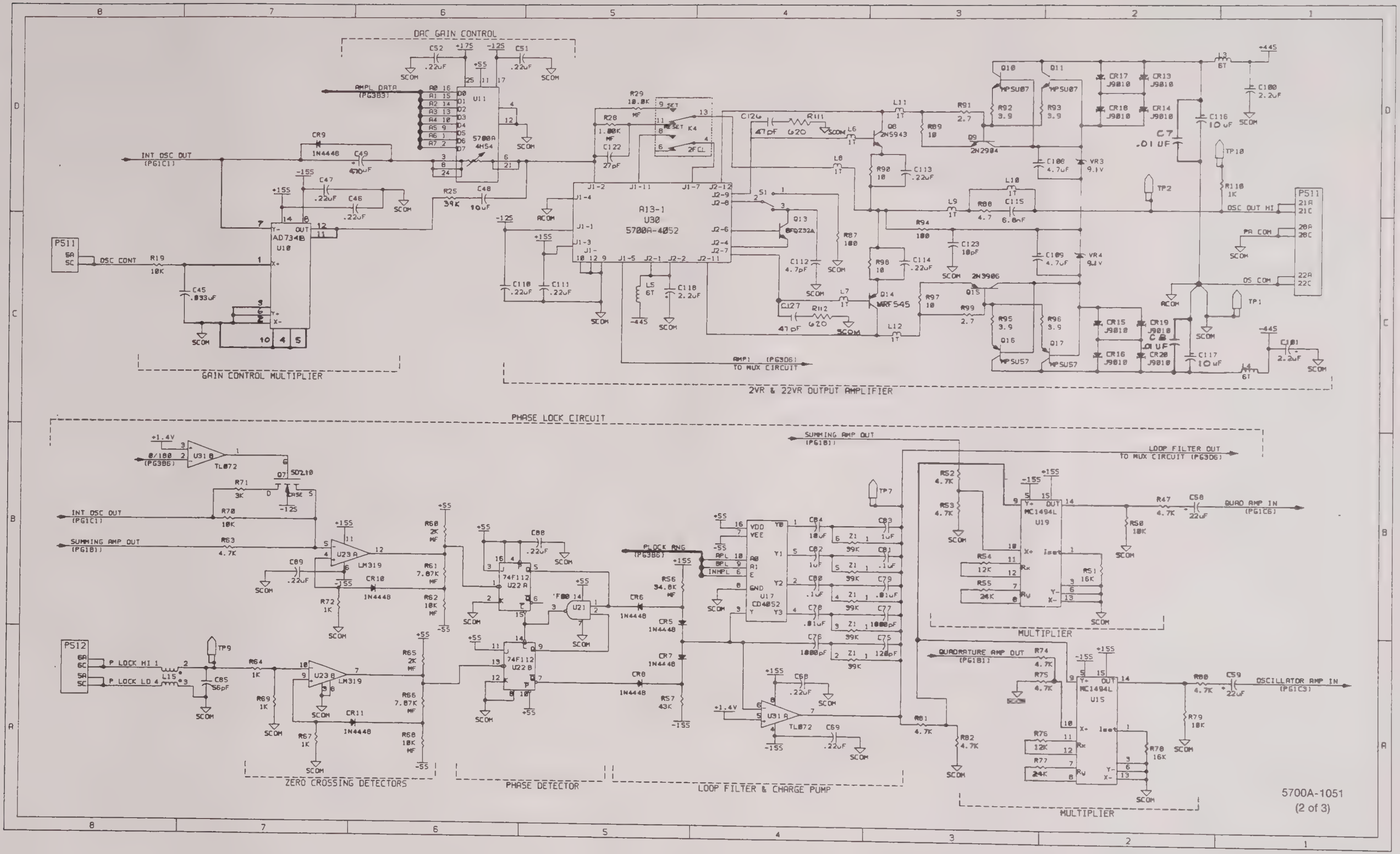
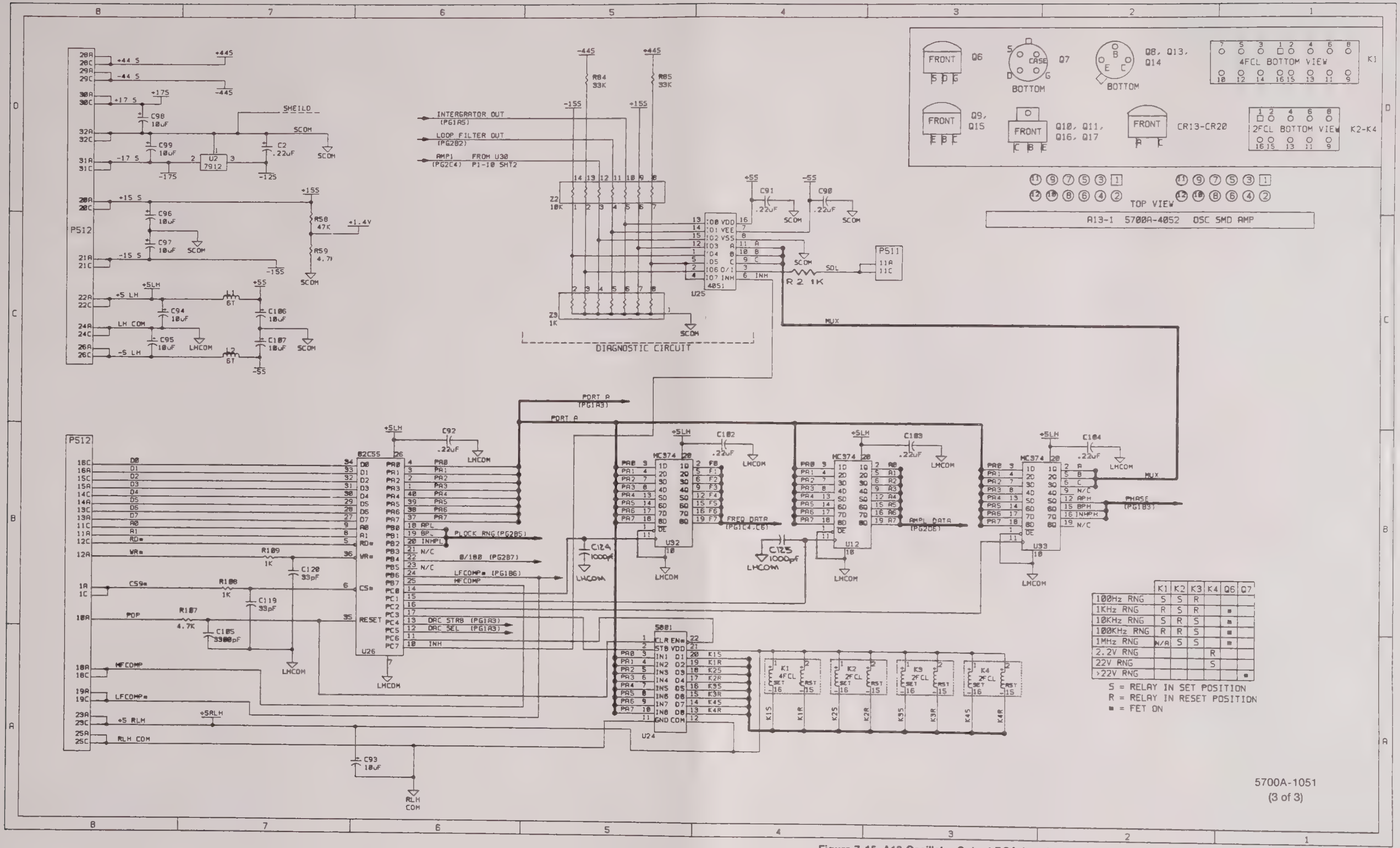


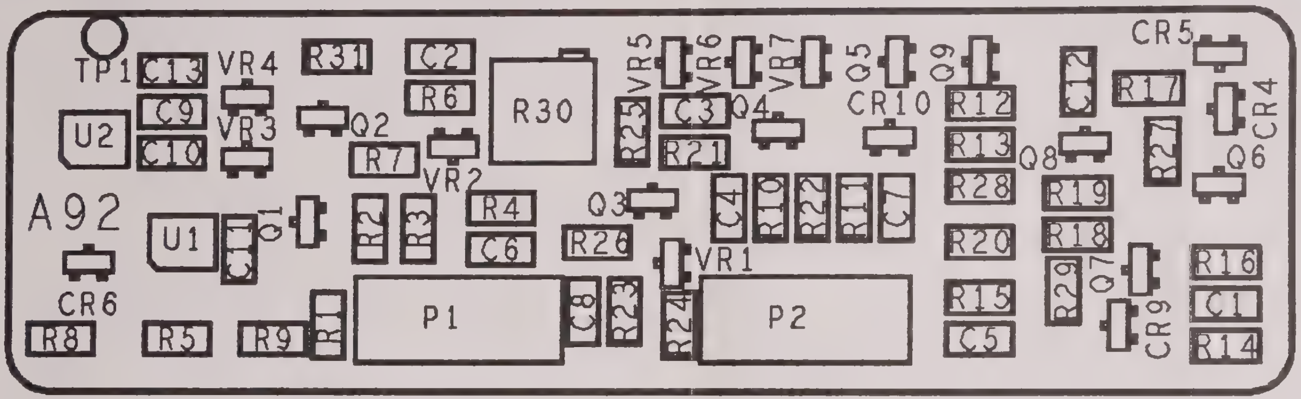
Figure 7-15. A13 Oscillator Output PCA (cont)



	K1	K2	K3	K4	Q6	Q7
100Hz RNG	S	S	R			
1KHz RNG	R	S	R		■	
10KHz RNG	S	R	S		■	
100KHz RNG	R	R	S		■	
1MHz RNG	N/A	S	S		■	
2.2V RNG				R		
22V RNG				S		
>22V RNG						■

S = RELAY IN SET POSITION
R = RELAY IN RESET POSITION
■ = FET ON

Figure 7-15. A13 Oscillator Output PCA (cont)



5700A-1652

Figure 7-16. A13A1 Oscillator Wideband SMD PCA

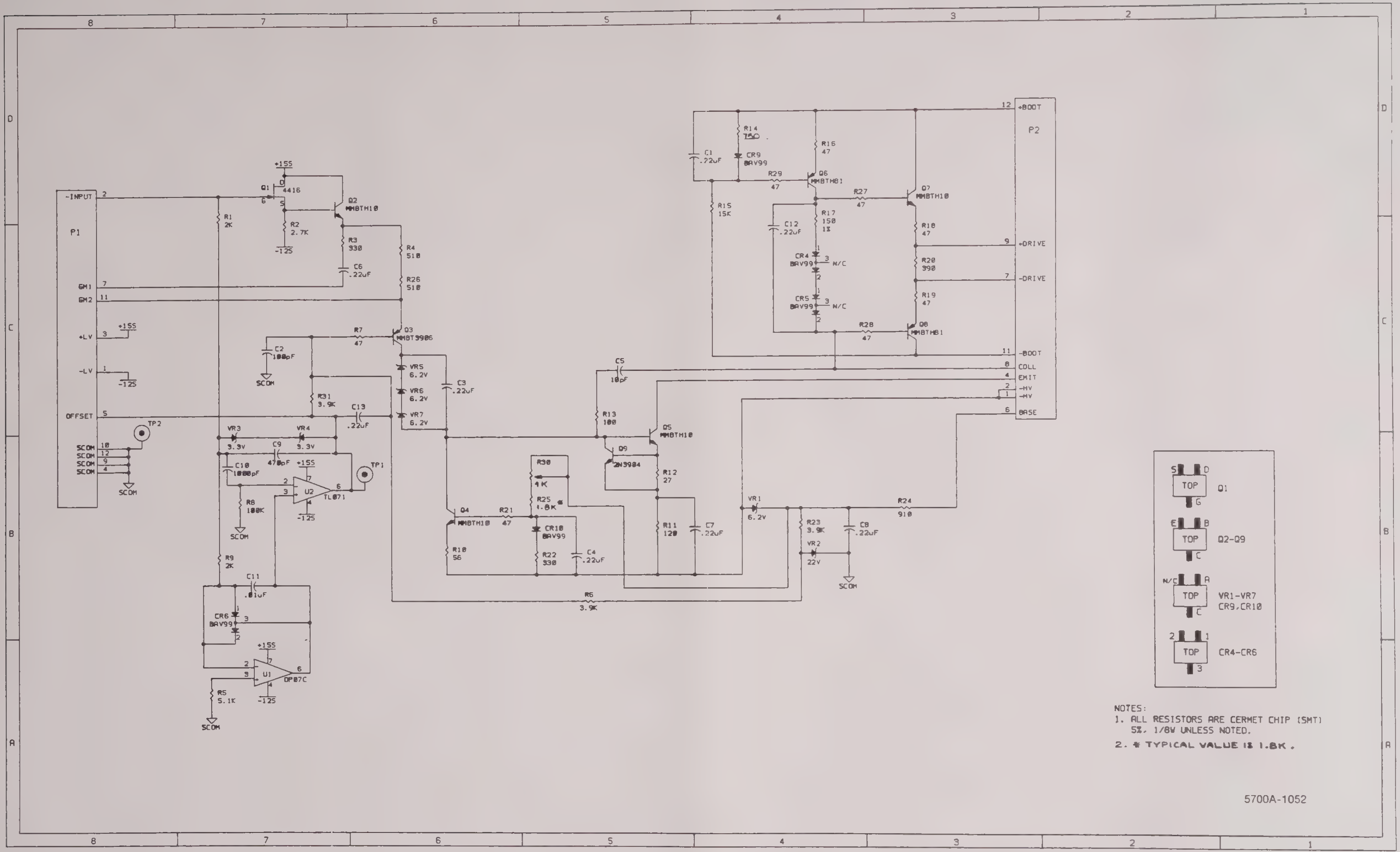


Figure 7-16. A13A1 Oscillator Wideband SMD PCA (cont)

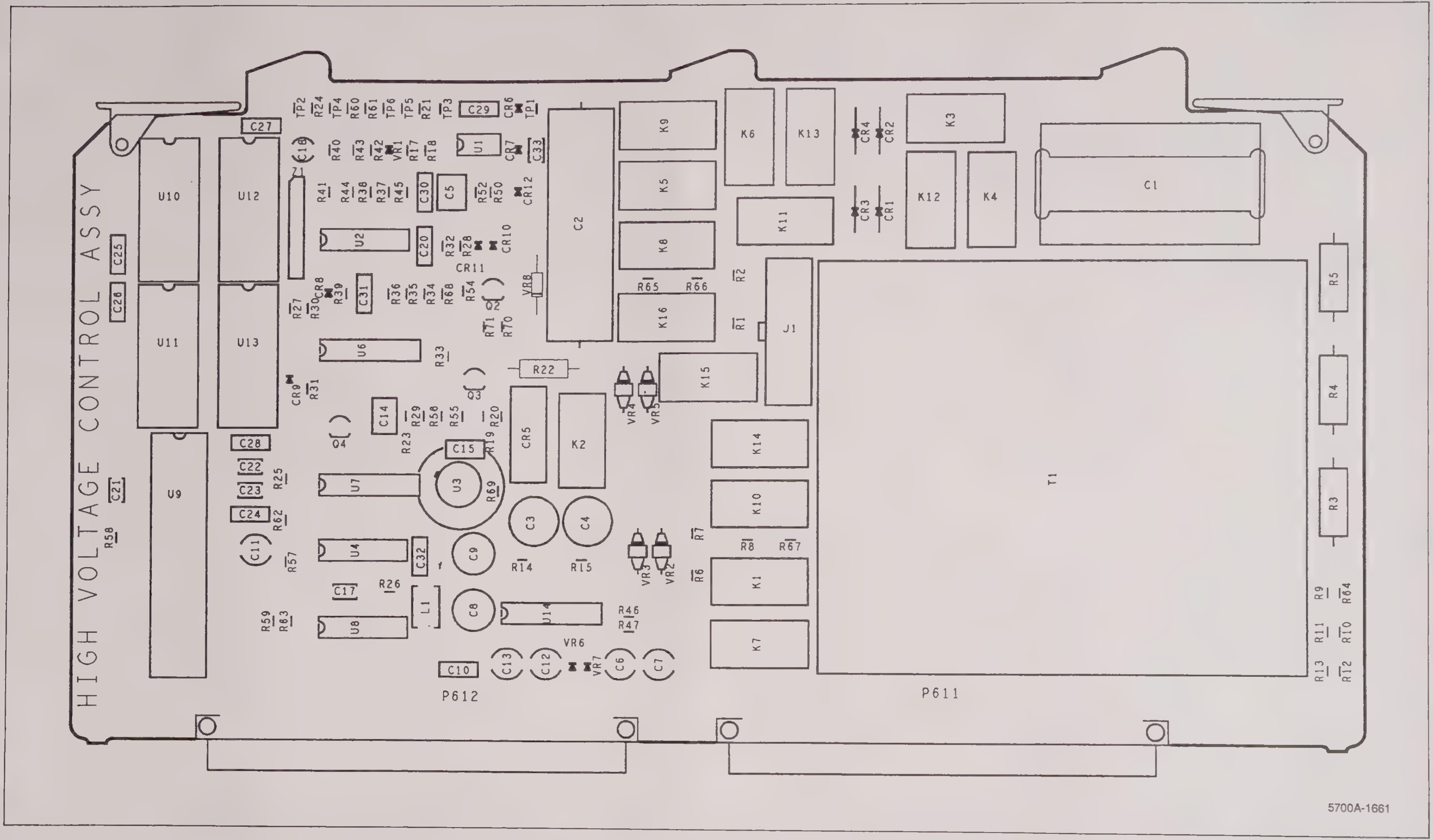
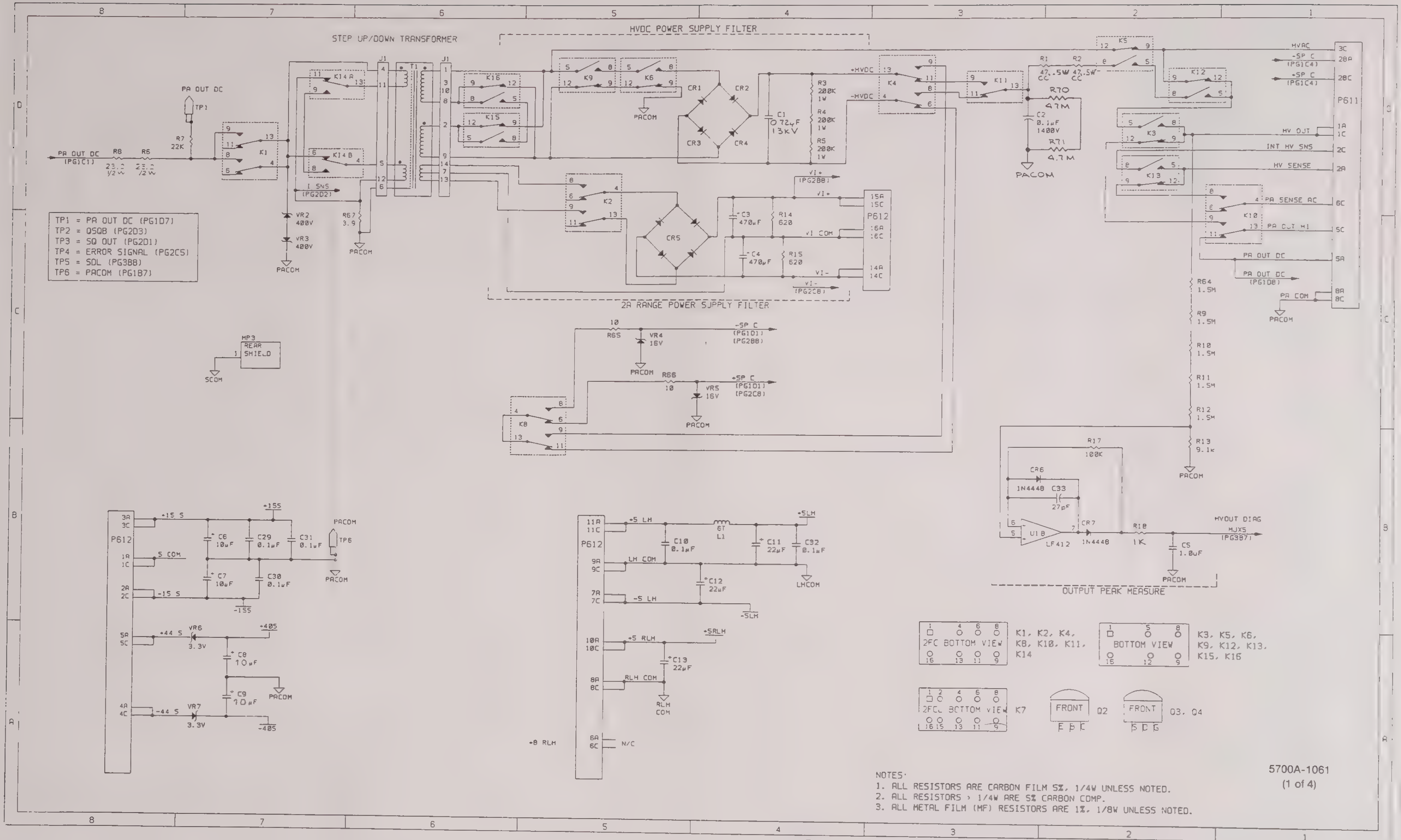


Figure 7-17. A14 High Voltage Control PCA



NOTES:
1. ALL RESISTORS ARE CARBON FILM 5%, 1/4W UNLESS NOTED.
2. ALL RESISTORS > 1/4W ARE 5% CARBON COMP.
3. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.

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Figure 7-17. A14 High Voltage Control PCA (cont)

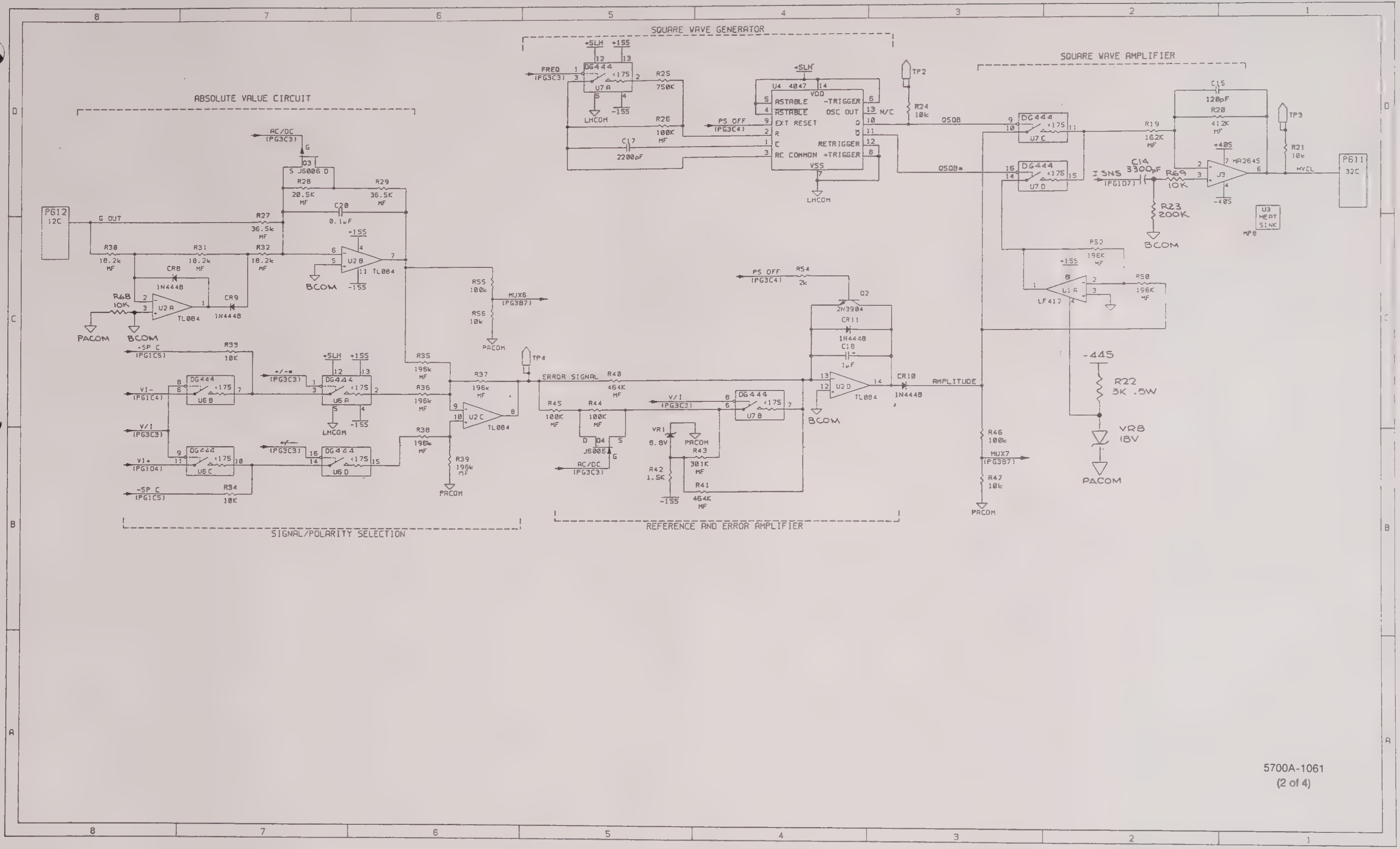

Figure 7-17. A14 High Voltage Control PCA (cont)

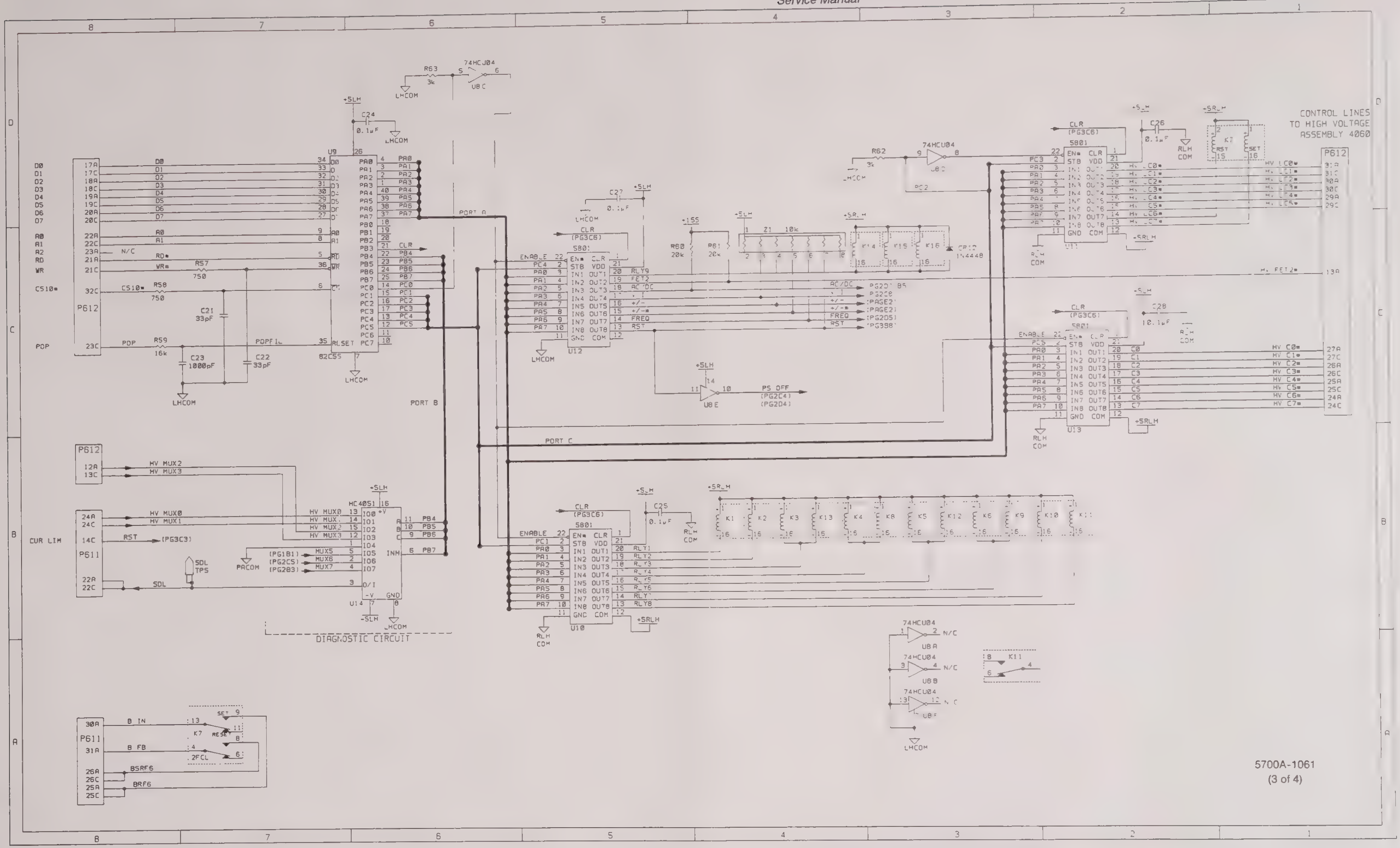

Figure 7-17. A14 High Voltage Control PCA (cont)

	HIGH VOLTAGE A15 ASSEMBLY														HIGH VOLTAGE CONTROL A14 ASSEMBLY																							
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K14	Q10	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	Q3	Q4	U6A	U6B	U6C	U6D	U7A	U7B
DORMANT	R	R	R											■							R												■					
AC 220V RANGE	R	R	R											■							R			■									■					
DC 220V RANGE	R	R	R											■							R												■					
AC 1100V RANGE	R	R	R	■		■								■	■		■				R						■	1	1	1			■					
DC +1100V RANGE	S	R	S		■	■	■						■	■	■		■		■	■	R		■		■	■	■						■					
DC -1100V RANGE	S	R	S		■	■	■						■	■	■		■	■	■	■	R	■	■			■	■									■		
AC 2.2A RANGE	R	R	R								■	■			■	■			■		R					■					■	■		■	■	■		■
DC +2.2A RANGE	R	R	R								■	■			■	■			■		R					■								■	■	■		■
DC -2.2A RANGE	R	R	R								■	■			■	■			■		R					■							■	■	■			■
OFFSET CAL HR7 RNET	S	R	S		■		■		■				■	■							R												■					
GAIN CAL HR7 RNET	R	S	S					■						■							R												■					
AC 220V AC FREQ CHAR	R	R	R								■	■		■							R			■									■					
AC 1100V AC FREQ CHAR	R	R	R	■		■		■		■	■	■		■	■		■				R						■						■					
OFFSET CAL CURRENT RNET	R	R	R								■	■			■	■			■		R					■								■	■	■		■
GAIN CAL CURRENT RNET	R	R	R								■	■			■	■			■		R					■								■	■	■		■
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K14	Q10	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	Q3	Q4	U6A	U6B	U6C	U6D	U7A	U7B

R = RESET POSITION FOR LATCHING RELAYS
S = SET POSITION FOR LATCHING RELAYS
■ = ENERGIZED FOR NON-LATCHING RELAYS
■ = ON FOR FETS
1 = ENERGIZED DURING OPERATION BELOW 120Hz ONLY
RELAY K7 IS SET DURING CALIBRATION OF THE 1.9 OHM ON THE OHMS CAL ASSEMBLY

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Figure 7-17. A14 High Voltage Control PCA (cont)

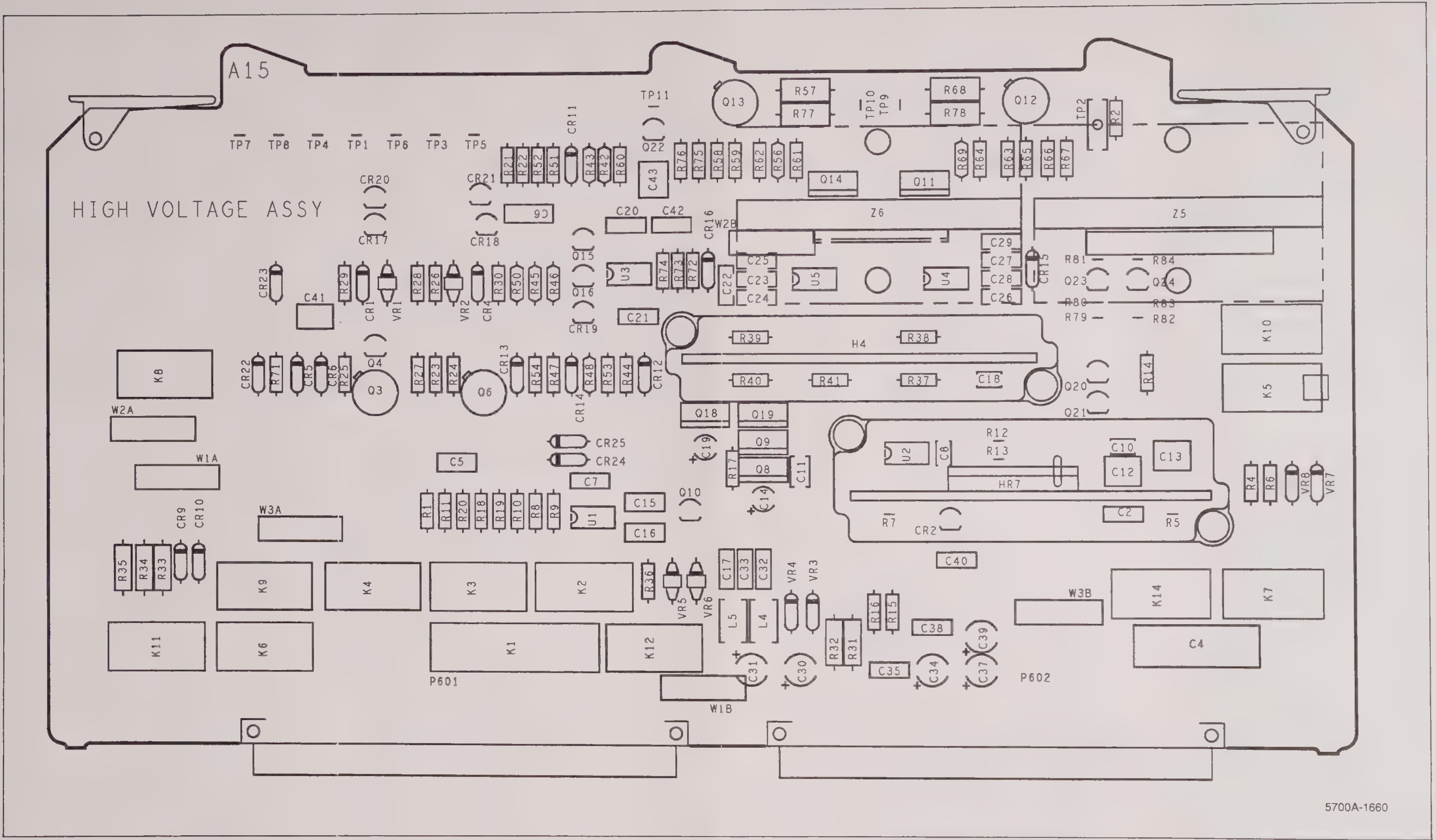
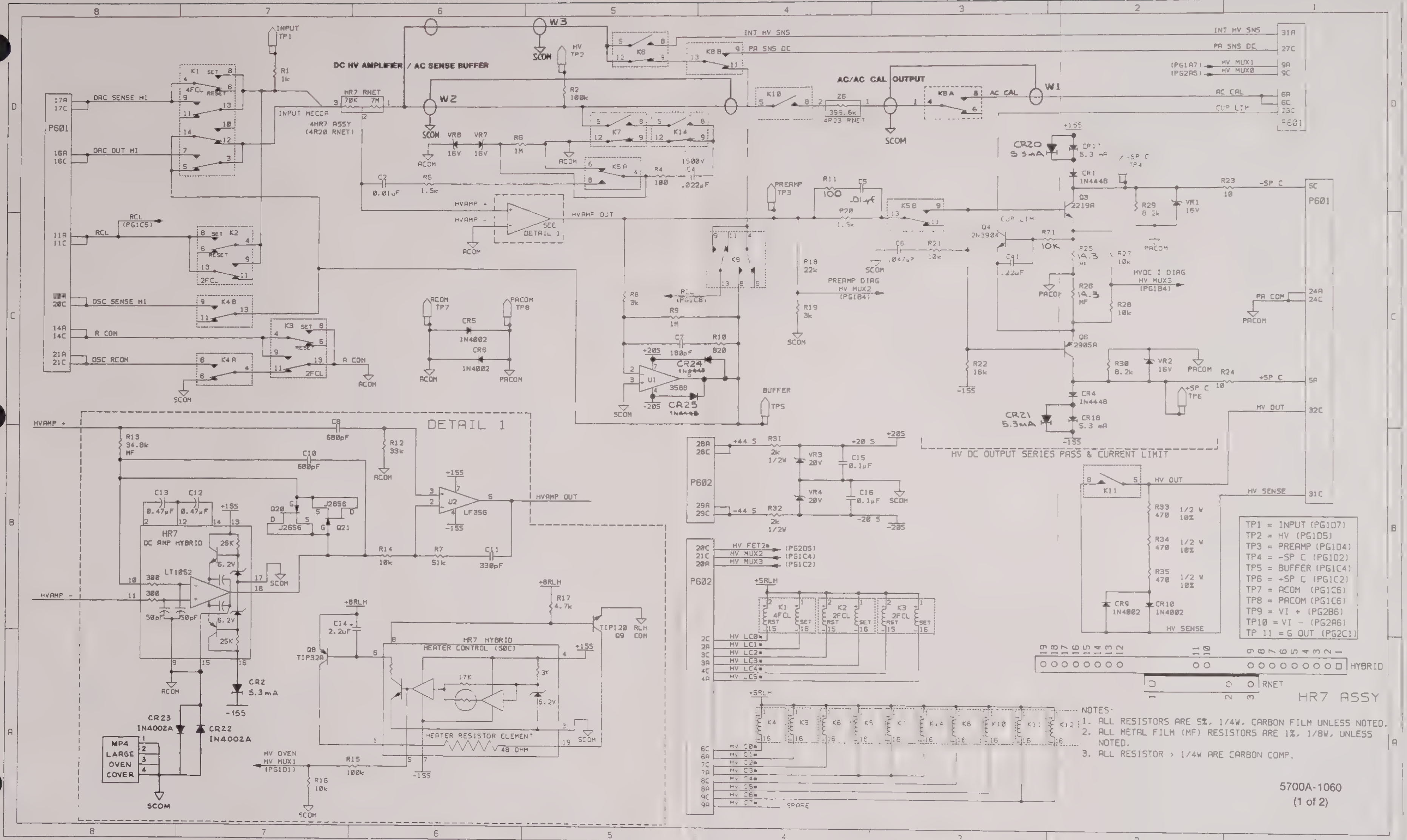


Figure 7-18. A15 High Voltage/High Current PCA



TP1 = INPUT (PG1D7)
TP2 = HV (PG1D5)
TP3 = PREAMP (PG1D4)
TP4 = -SP C (PG1D2)
TP5 = BUFFER (PG1C4)
TP6 = +SP C (PG1C2)
TP7 = ACOM (PG1C6)
TP8 = PACOM (PG1C6)
TP9 = VI + (PG2B6)
TP10 = VI - (PG2A6)
TP 11 = G OUT (PG2C1)

NOTES:
1. ALL RESISTORS ARE 5%, 1/4W, CARBON FILM UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W, UNLESS NOTED.
3. ALL RESISTOR > 1/4W ARE CARBON COMP.

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Figure 7-18. A15 High Voltage/High Current PCA (cont)

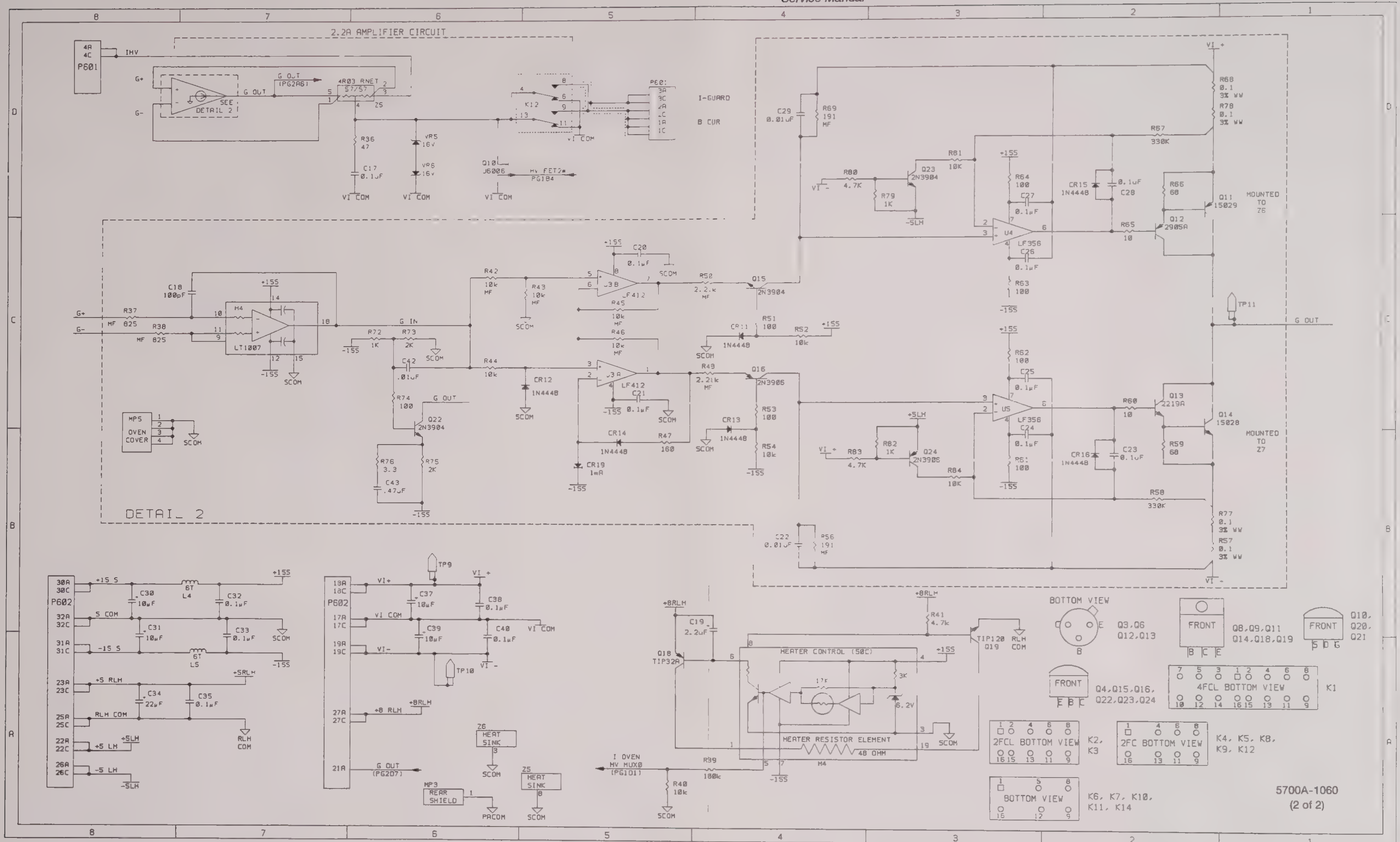


Figure 7-18. A15 High Voltage/High Current PCA (cont)

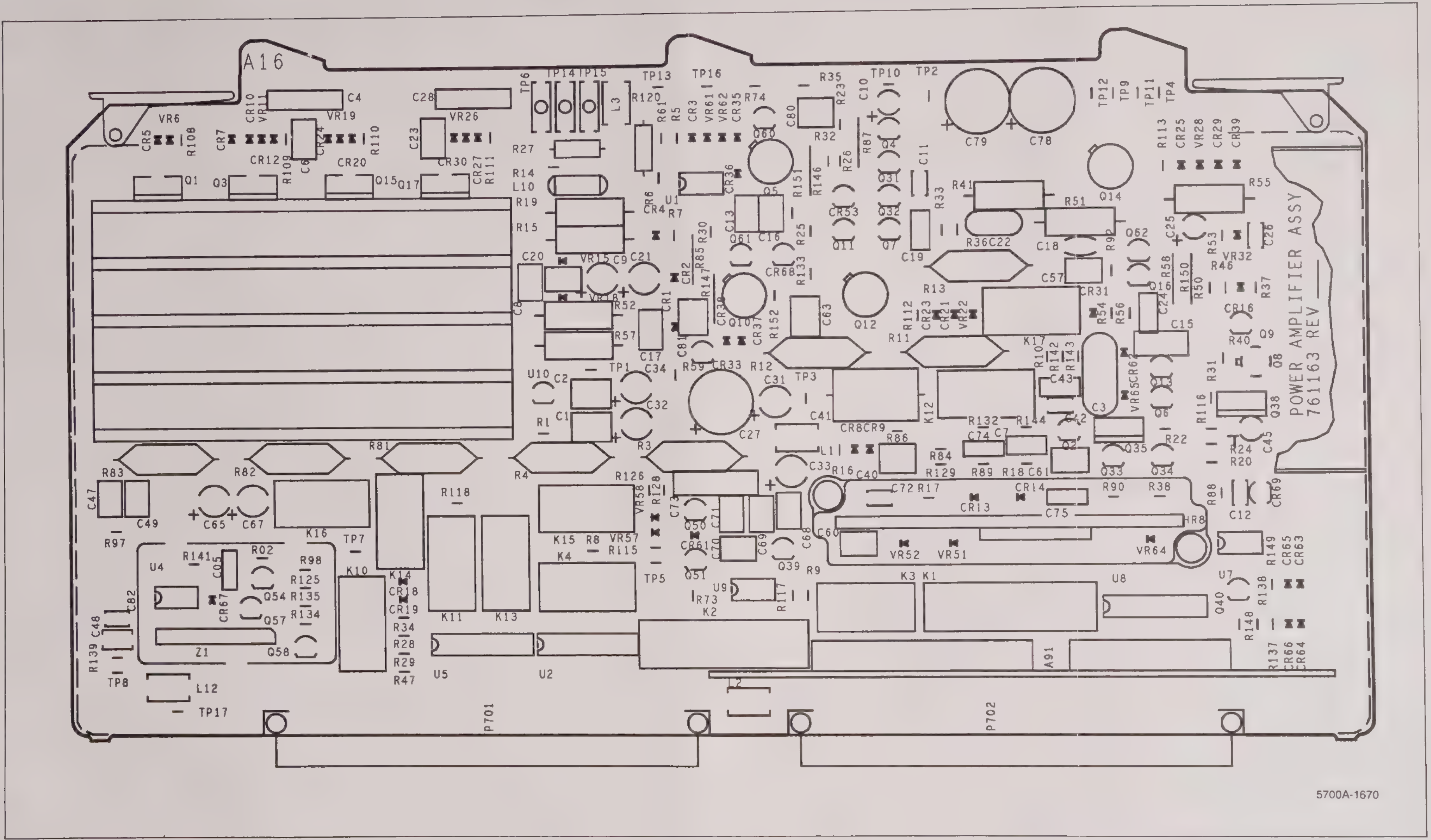
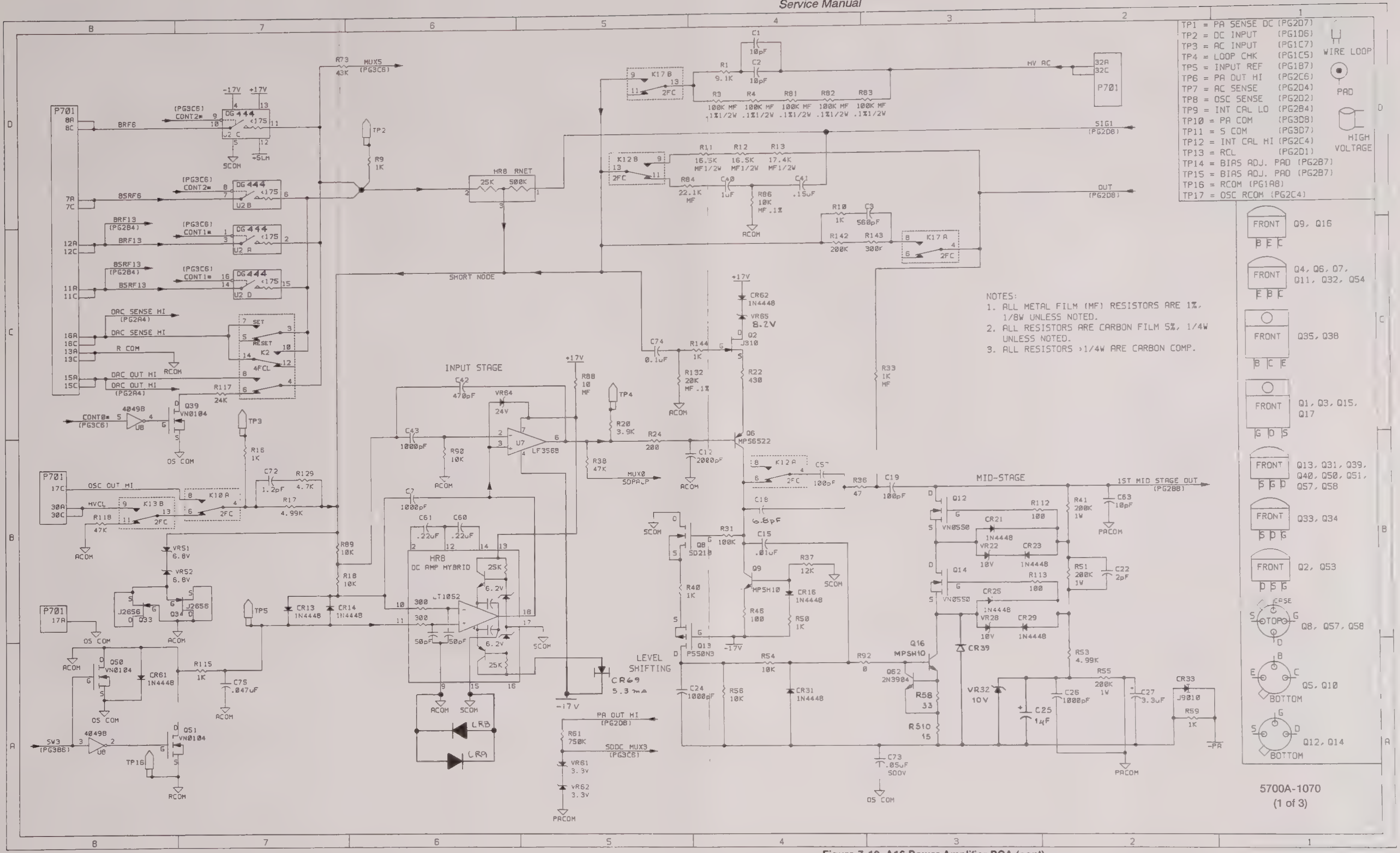


Figure 7-19. A16 Power Amplifier PCA



TP1 = PA SENSE DC (PG2D7)
TP2 = DC INPUT (PG1D6)
TP3 = AC INPUT (PG1C7)
TP4 = LOOP CHK (PG1C5)
TP5 = INPUT REF (PG1B7)
TP6 = PA OUT HI (PG2C6)
TP7 = AC SENSE (PG2D4)
TP8 = OSC SENSE (PG2D2)
TP9 = INT CAL LO (PG2B4)
TP10 = PA COM (PG3D8)
TP11 = S COM (PG3D7)
TP12 = INT CAL HI (PG2C4)
TP13 = RCL (PG2D1)
TP14 = BIAS ADJ. PAD (PG2B7)
TP15 = BIAS ADJ. PAD (PG2B7)
TP16 = RCOM (PG1A8)
TP17 = OSC RCOM (PG2C4)

NOTES:

1. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.
2. ALL RESISTORS ARE CARBON FILM 5%, 1/4W UNLESS NOTED.
3. ALL RESISTORS >1/4W ARE CARBON COMP.

Figure 7-19. A16 Power Amplifier PCA (cont)

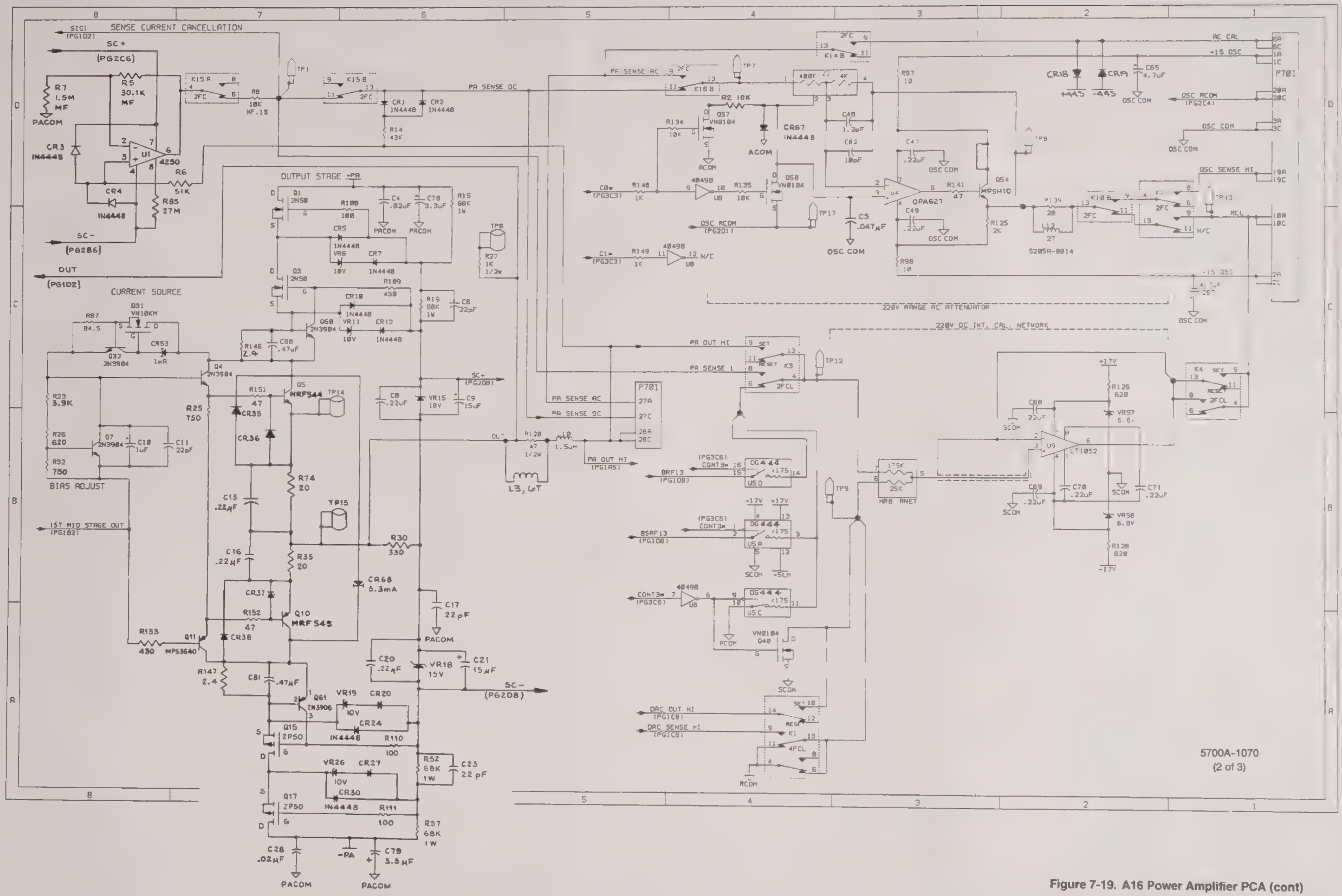
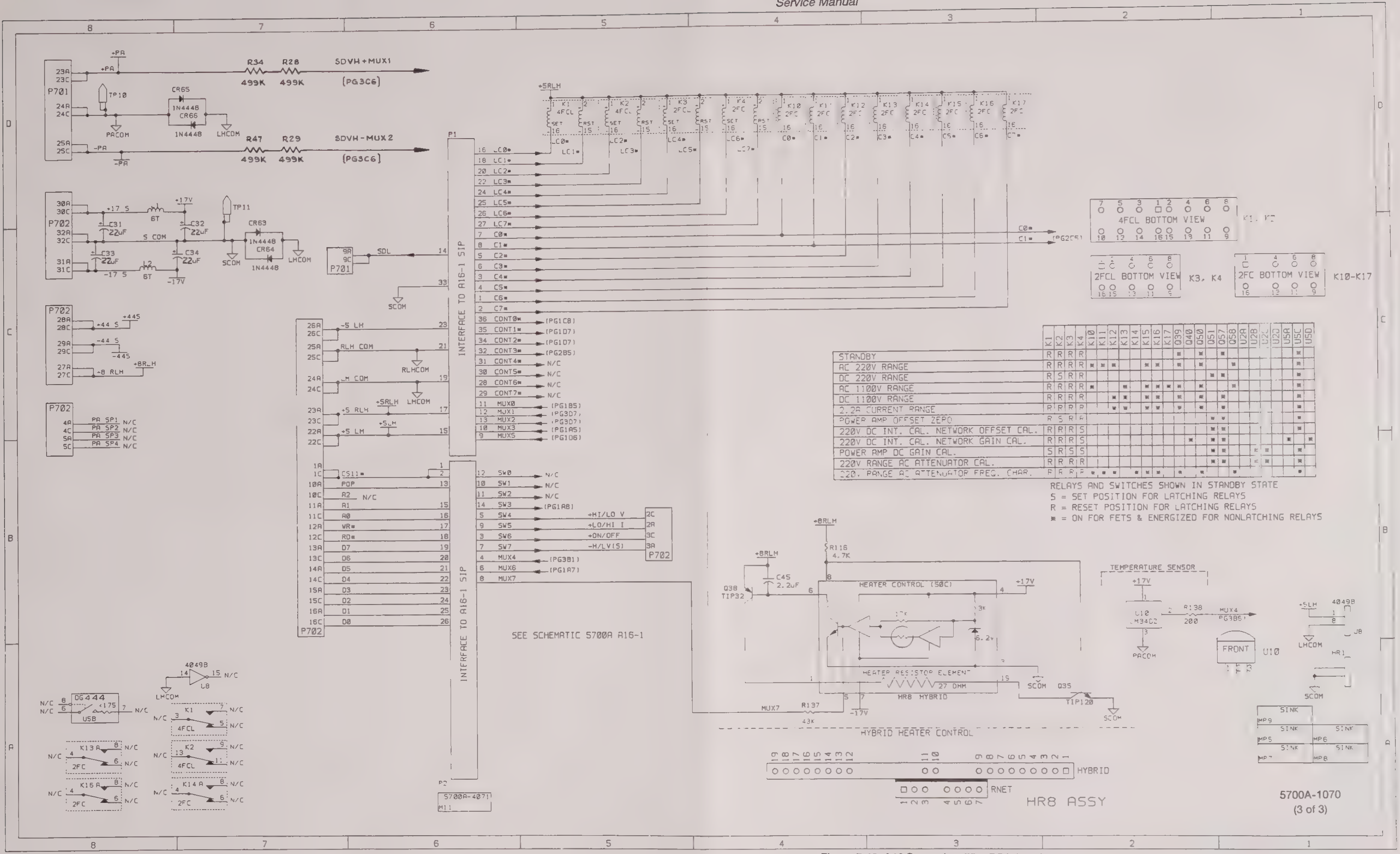


Figure 7-19. A16 Power Amplifier PCA (cont)



	K1	K2	K3	K4	K10	K11	K12	K13	K14	K15	K16	K17	Q39	Q40	Q50	Q51	Q57	Q58	U2A	U2B	U2C	U2D	U5A	U5C	U5D
STANDBY	R	R	R	R									■		■		■							■	
AC 220V RANGE	R	R	R	R	■	■	■			■	■		■		■			■						■	
DC 220V RANGE	R	S	R	R												■	■							■	
AC 1100V RANGE	R	R	R	R	■			■		■	■	■	■		■			■						■	
DC 1100V RANGE	R	R	R	R			■	■		■	■		■		■		■							■	
2.2A CURRENT RANGE	R	R	R	R			■	■		■	■		■		■		■							■	
POWER AMP OFFSET ZERO	R	S	R	R												■	■							■	
220V DC INT. CAL. NETWORK OFFSET CAL.	R	R	R	S												■	■							■	
220V DC INT. CAL. NETWORK GAIN CAL.	R	R	R	S										■		■	■						■		■
POWER AMP DC GAIN CAL.	S	R	S	S												■	■			■	■			■	
220V RANGE AC ATTENUATOR CAL.	R	R	R	R												■	■			■	■			■	
220V RANGE AC ATTENUATOR FREQ. CHAR.	R	R	R	R	■	■	■		■	■	■		■		■			■						■	

RELAYS AND SWITCHES SHOWN IN STANDBY STATE
S = SET POSITION FOR LATCHING RELAYS
R = RESET POSITION FOR LATCHING RELAYS
■ = ON FOR FETS & ENERGIZED FOR NONLATCHING RELAYS

Figure 7-19. A16 Power Amplifier PCA (cont)

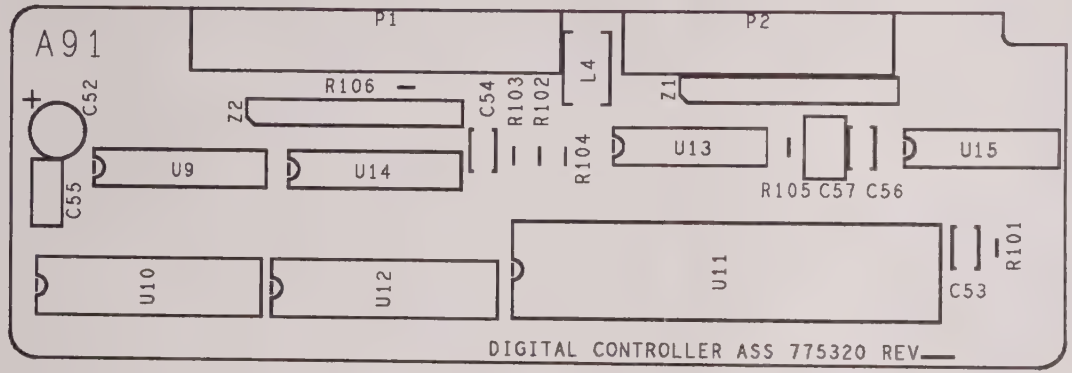


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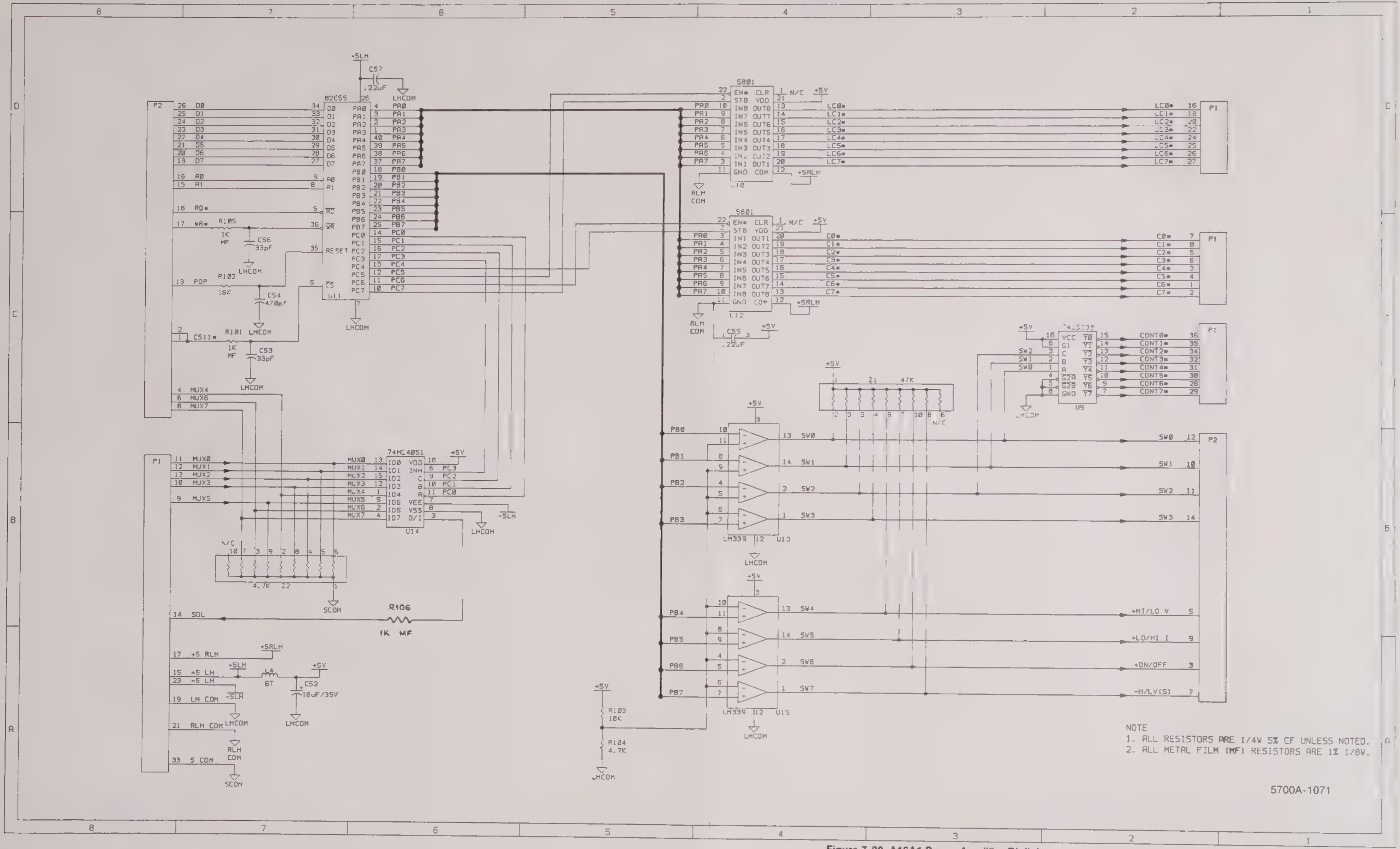
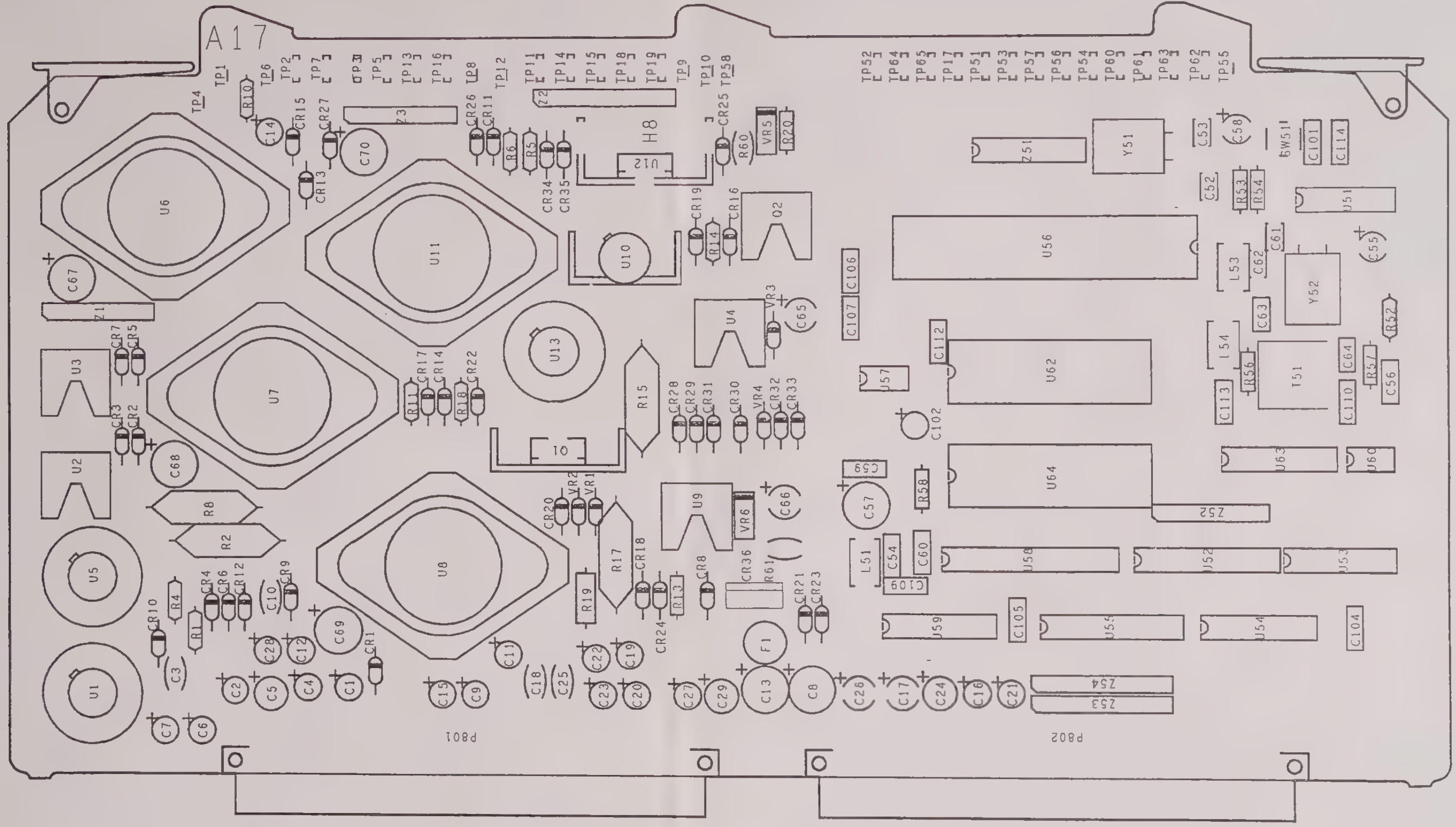
Figure 7-20. A16A1 Power Amplifier Digital Control SIP PCA



NOTE
1. ALL RESISTORS ARE 1/4W 5% CF UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1% 1/8W.

5700A-1071

Figure 7-20. A16A1 Power Amplifier Digital Control SIP PCA (cont)



5700A-1680

Figure 7-21. A17 Regulator/Guard Crossing PCA

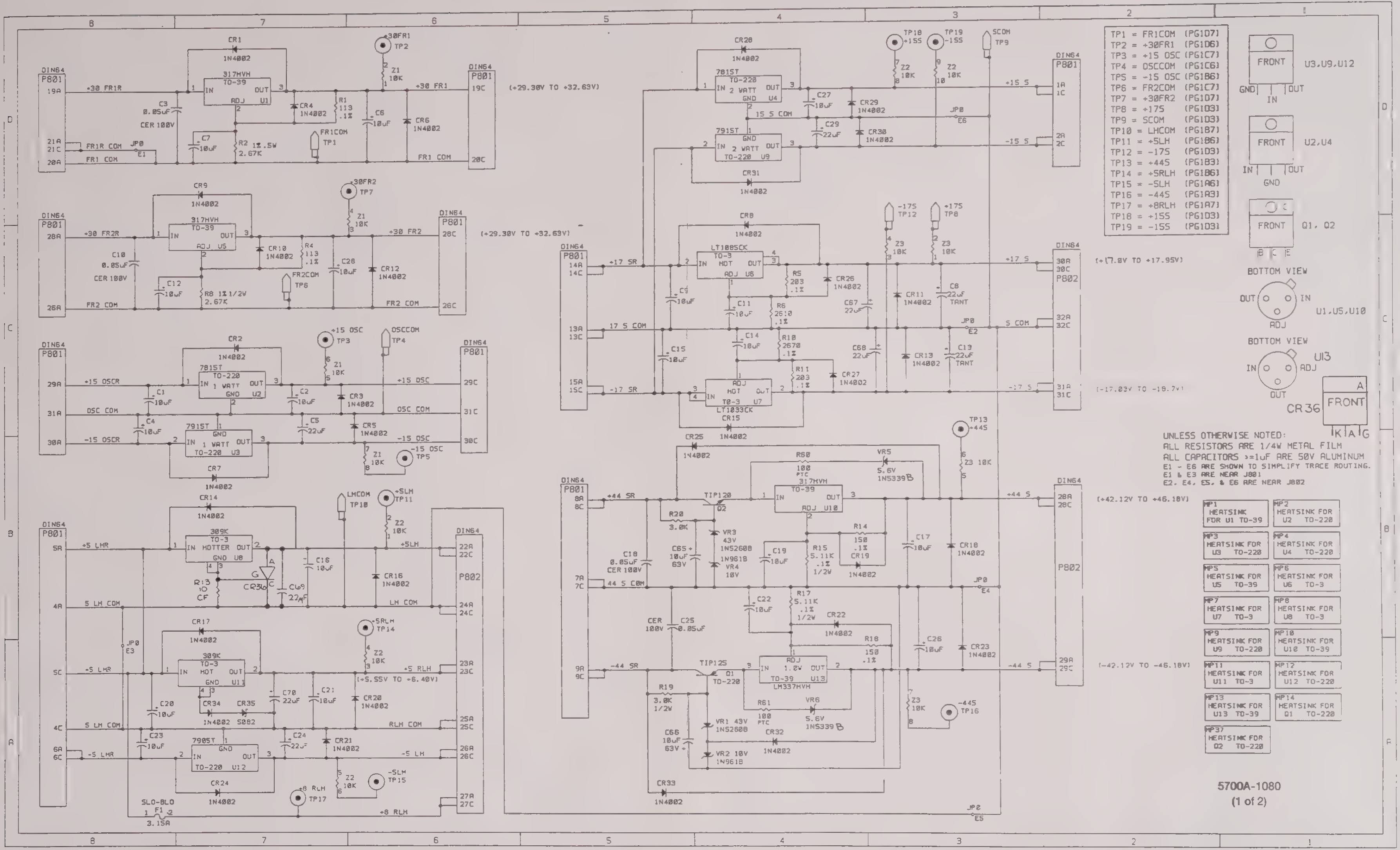
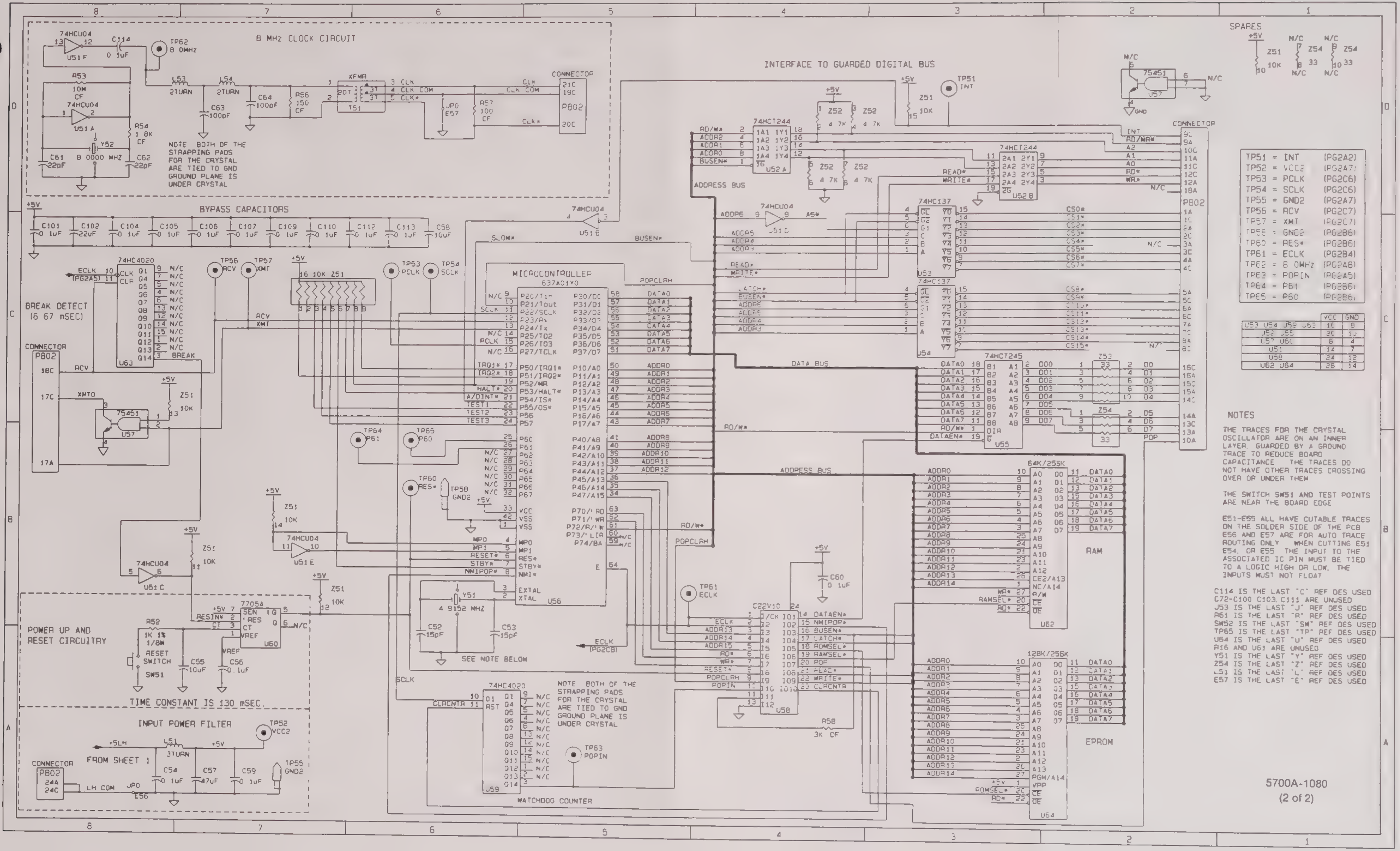


Figure 7-21. A17 Regulator/Guard Crossing PCA (cont)



TP51 = INT (PG2A2)
TP52 = VCC2 (PG2A7)
TP53 = PCLK (PG2C6)
TP54 = SCLK (PG2C6)
TP55 = GND2 (PG2A7)
TP56 = RCV (PG2C7)
TP57 = XMT (PG2C7)
TP58 = GND2 (PG2B6)
TP60 = RES* (PG2B6)
TP61 = ECLK (PG2B4)
TP62 = 8 0MHz (PG2A8)
TP63 = POPIN (PG2A5)
TP64 = P61 (PG2B6)
TP65 = P60 (PG2B6)

	VCC	GND
U53 U54 U59 U63	16	8
U52 U55	20	10
U57 U60	8	4
U51	14	7
U58	24	12
U62 U64	28	14

NOTES

THE TRACES FOR THE CRYSTAL OSCILLATOR ARE ON AN INNER LAYER. GUARDED BY A GROUND TRACE TO REDUCE BOARD CAPACITANCE THE TRACES DO NOT HAVE OTHER TRACES CROSSING OVER OR UNDER THEM

THE SWITCH SW51 AND TEST POINTS ARE NEAR THE BOARD EDGE

E51-E55 ALL HAVE CUTABLE TRACES ON THE SOLDER SIDE OF THE PCB E56 AND E57 ARE FOR AUTO TRACE ROUTING ONLY WHEN CUTTING E51 E54. OR E55 THE INPUT TO THE ASSOCIATED IC PIN MUST BE TIED TO A LOGIC HIGH OR LOW. THE INPUTS MUST NOT FLOAT

C114 IS THE LAST "C" REF DES USED
C72-C100 C103. C111 ARE UNUSED
J53 IS THE LAST "J" REF DES USED
R61 IS THE LAST "R" REF DES USED
SW52 IS THE LAST "SW" REF DES USED
TP65 IS THE LAST "TP" REF DES USED
U64 IS THE LAST "U" REF DES USED
R16 AND U61 ARE UNUSED
Y51 IS THE LAST "Y" REF DES USED
Z54 IS THE LAST "Z" REF DES USED
L51 IS THE LAST "L" REF DES USED
E57 IS THE LAST "E" REF DES USED

Figure 7-21. A17 Regulator/Guard Crossing PCA (cont)

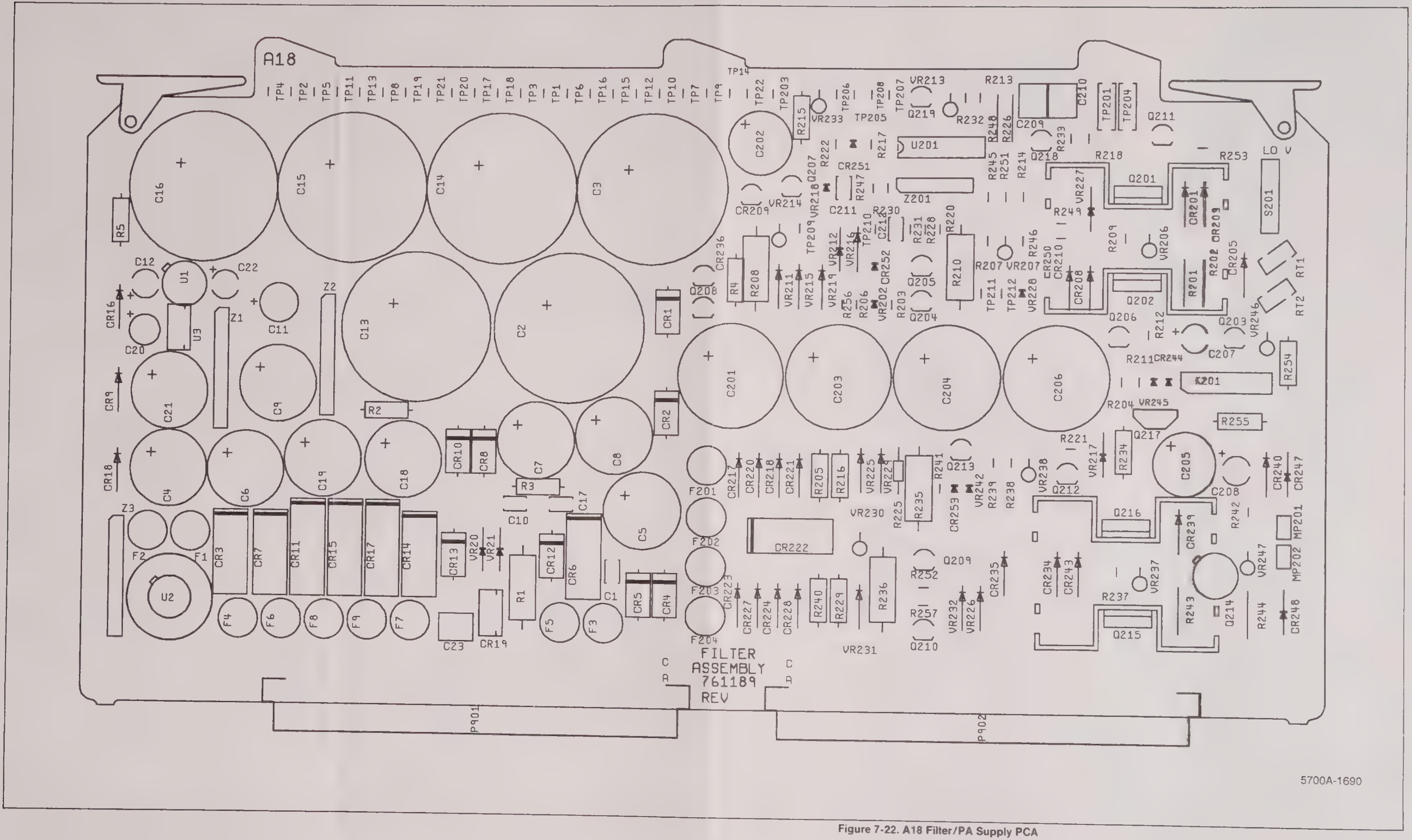


Figure 7-22. A18 Filter/PA Supply PCA

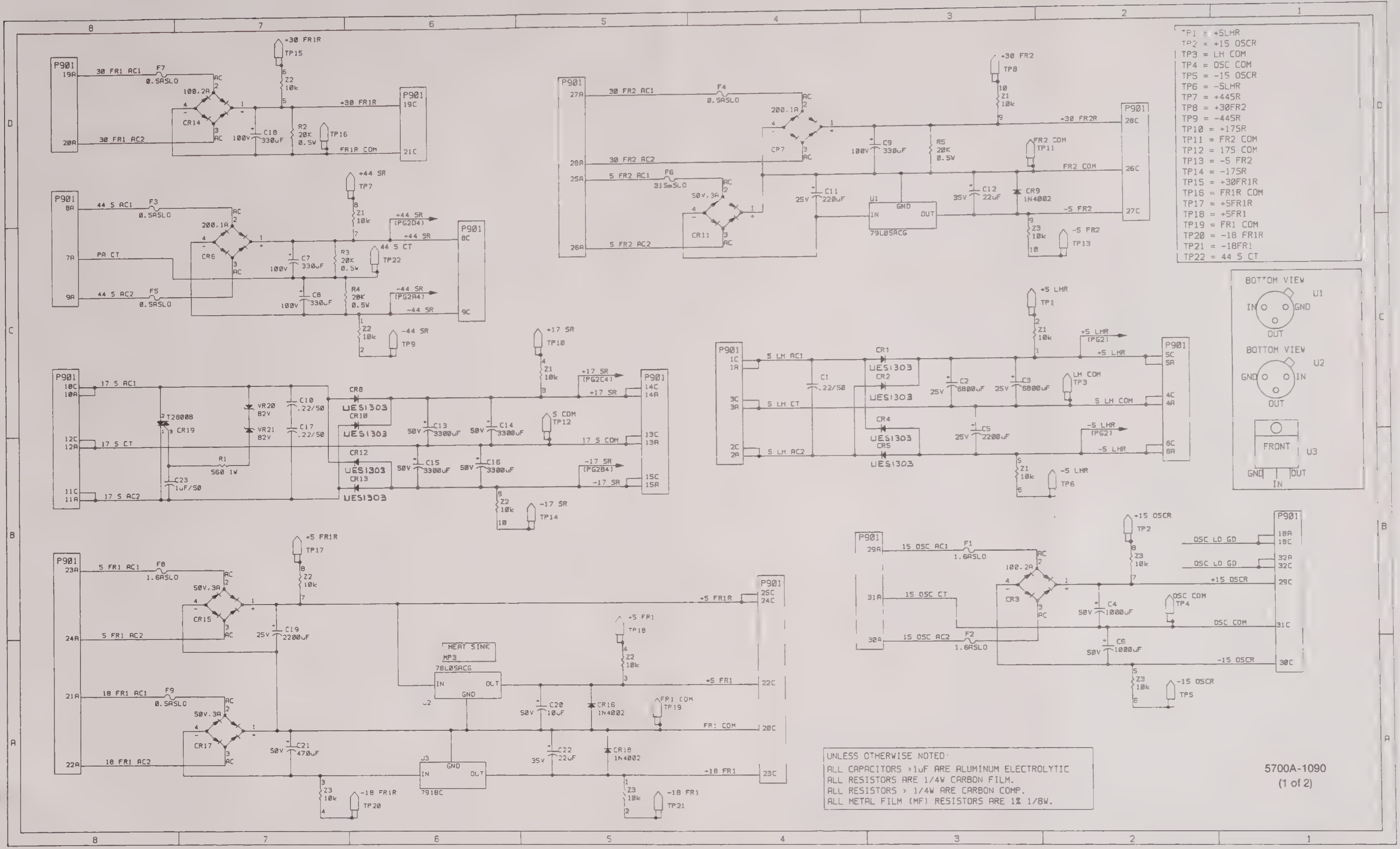


Figure 7-22. A18 Filter/PA Supply PCA (cont)

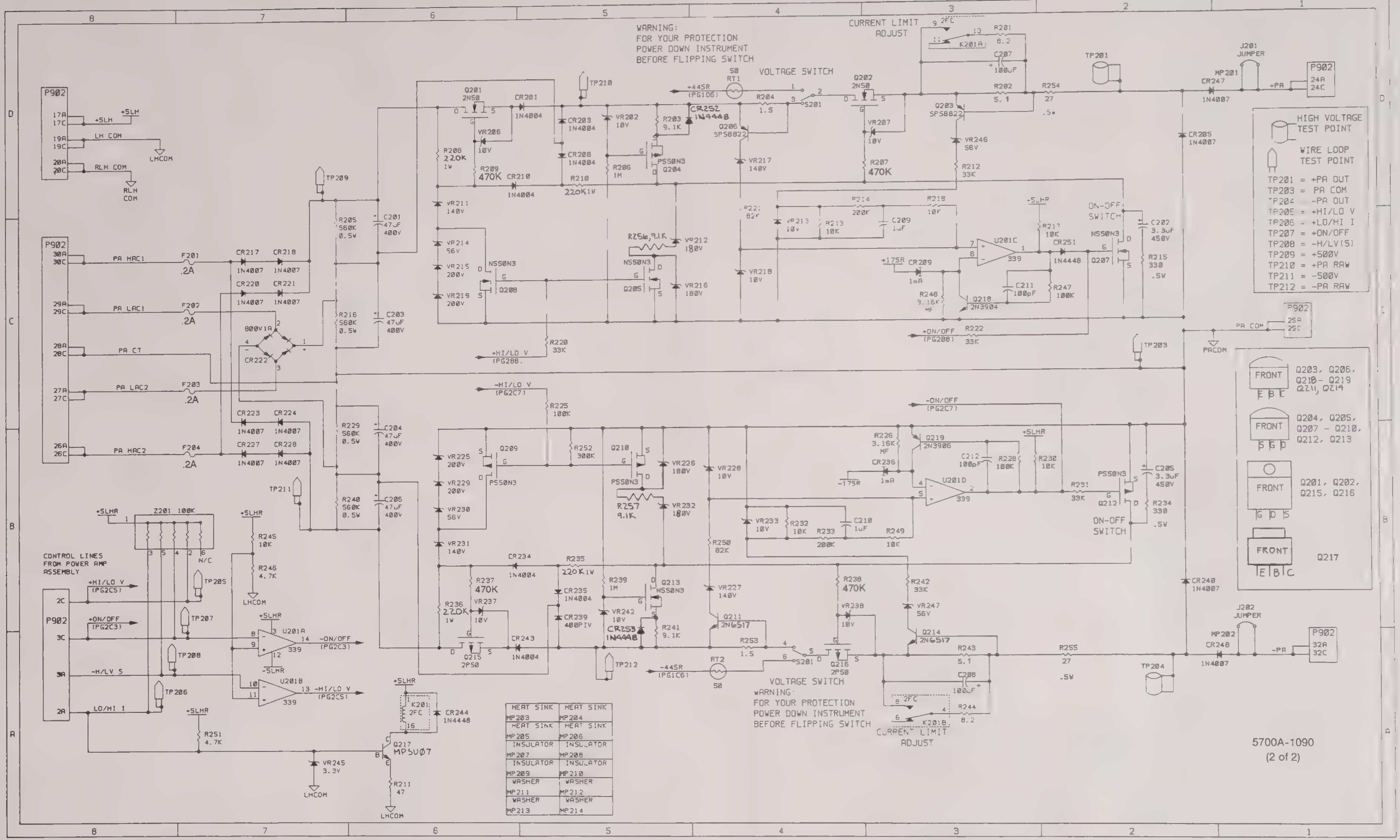


Figure 7-22. A18 Filter/PA Supply PCA (cont)

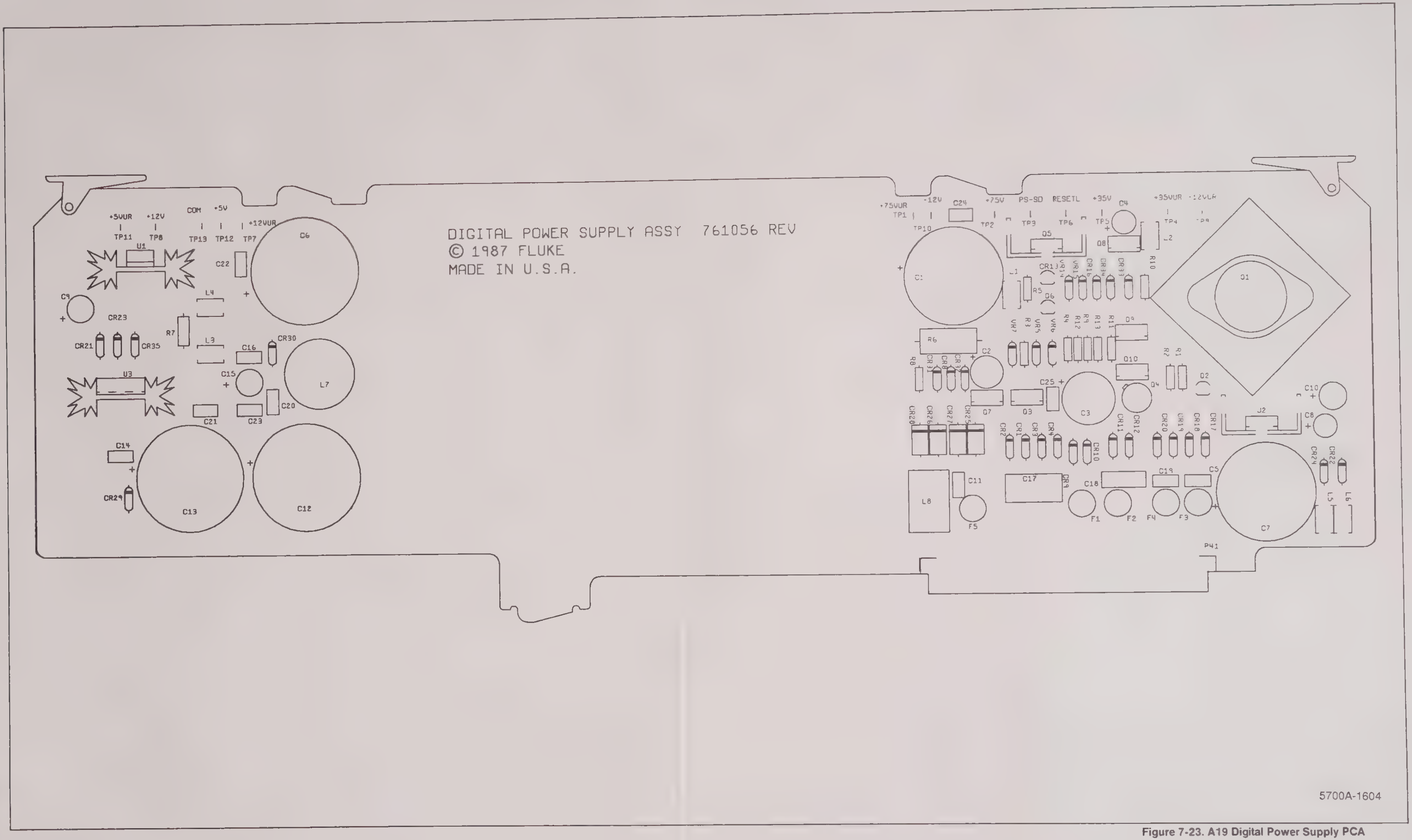


Figure 7-23. A19 Digital Power Supply PCA

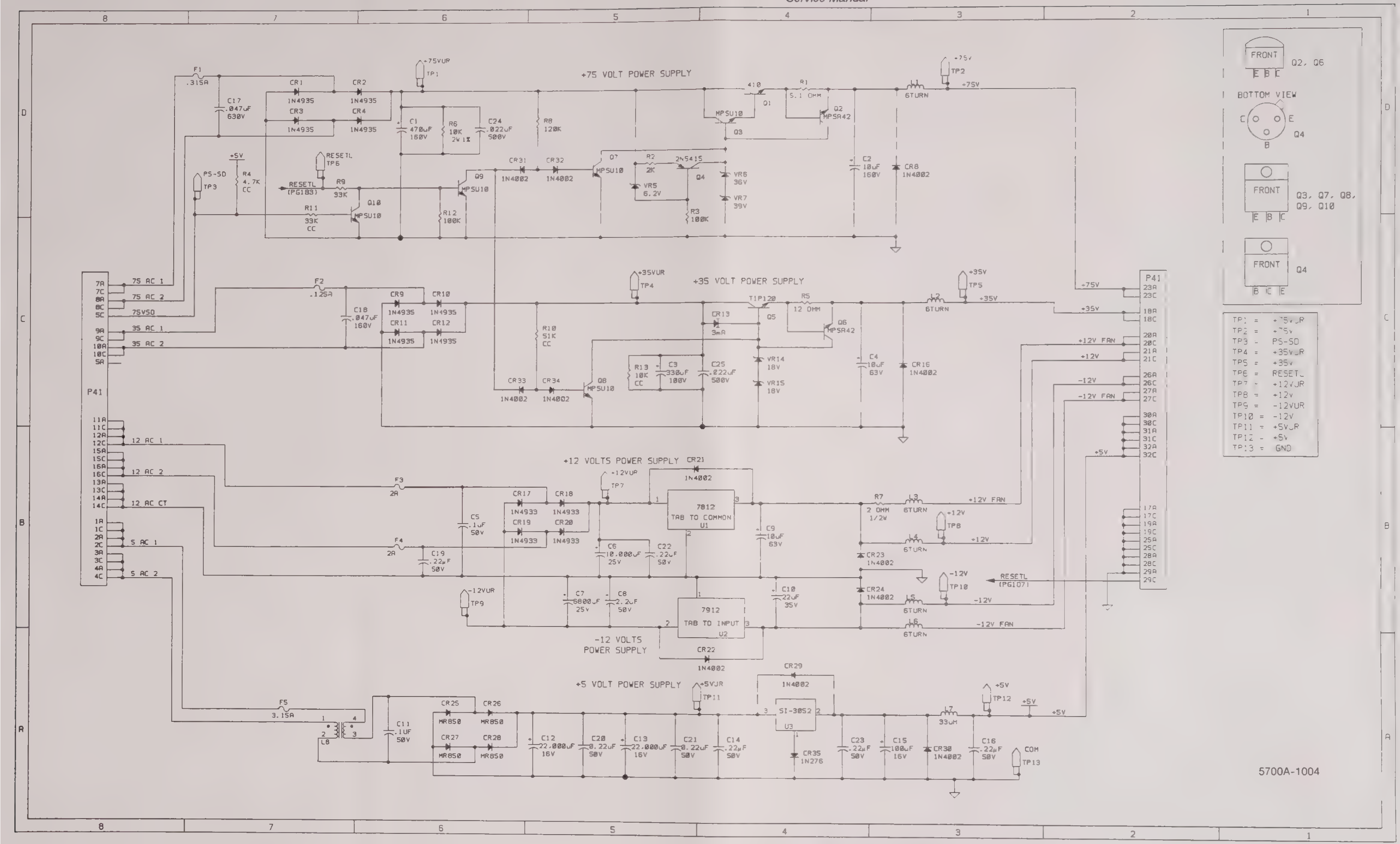


Figure 7-23. A19 Digital Power Supply PCA (cont)

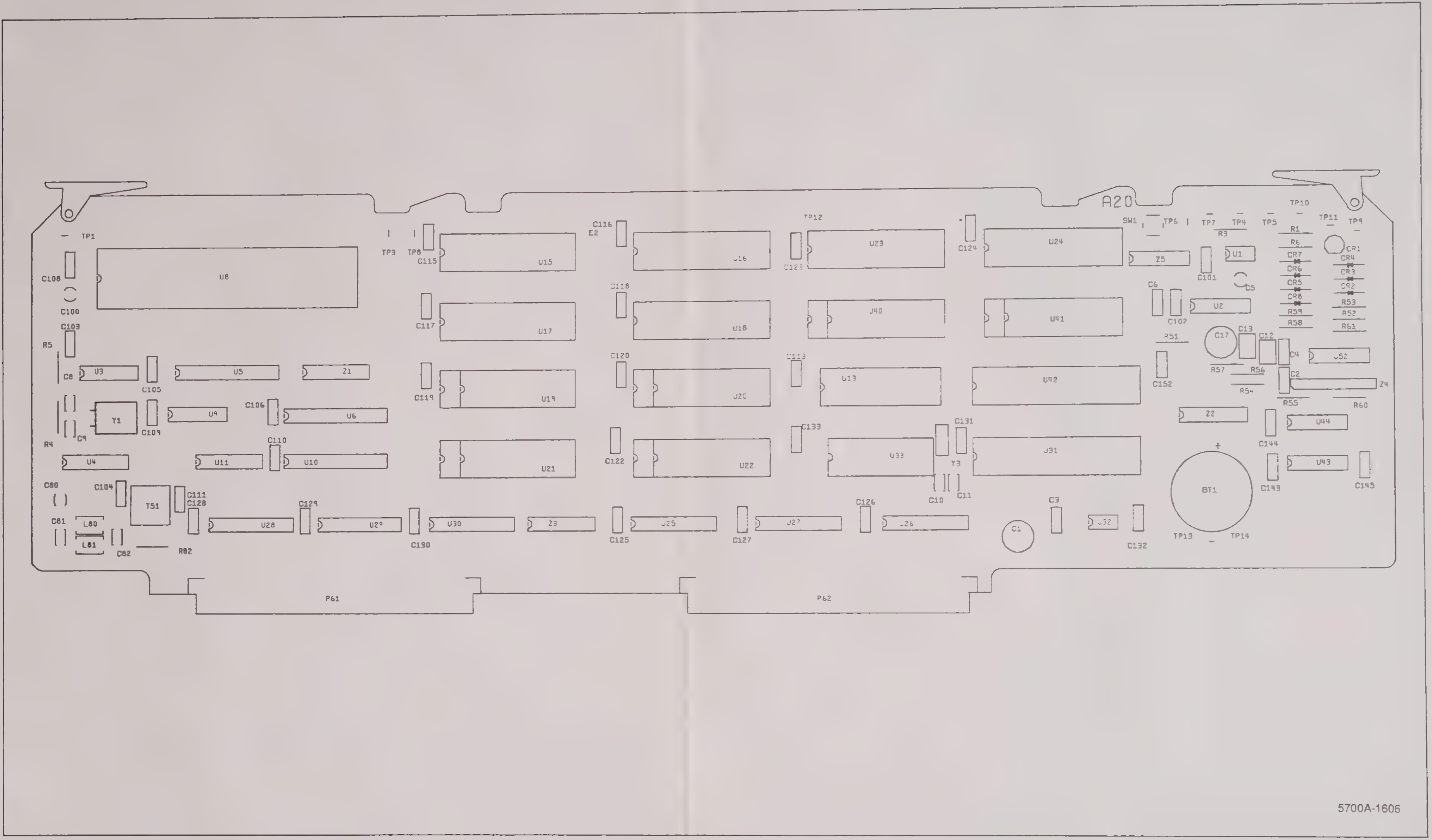


Figure 7-24. A20 CPU PCA

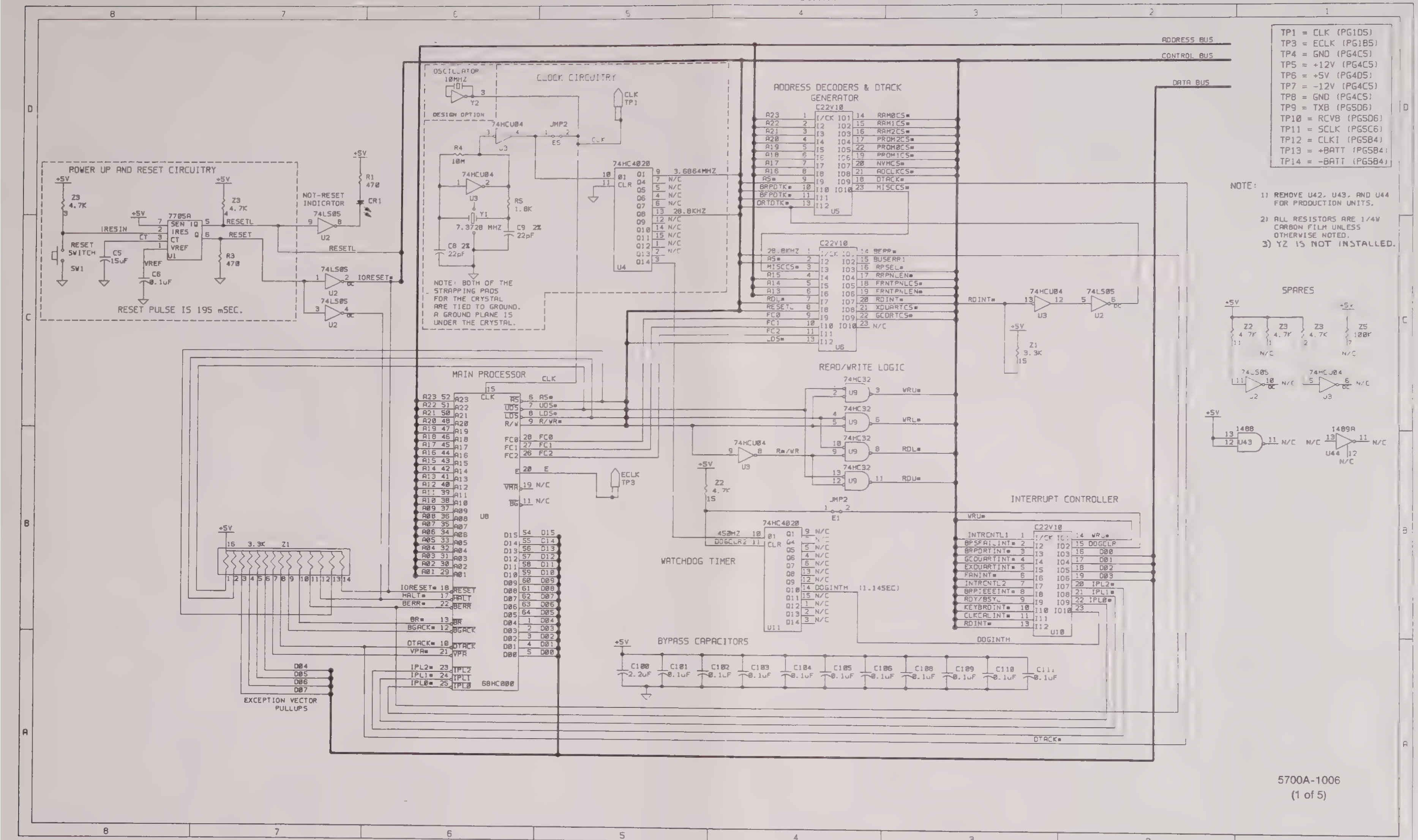


Figure 7-24. A20 CPU PCA (cont)

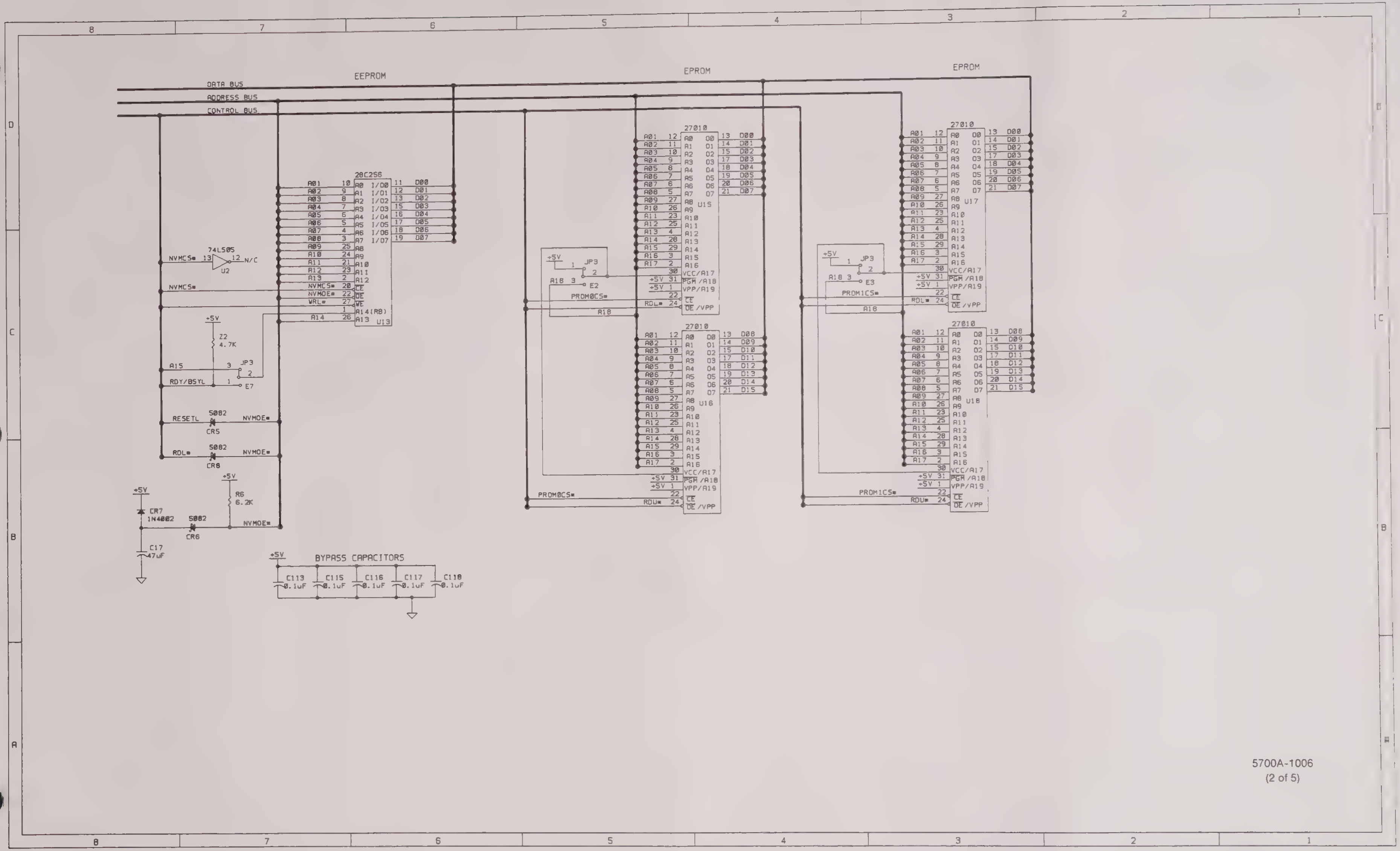
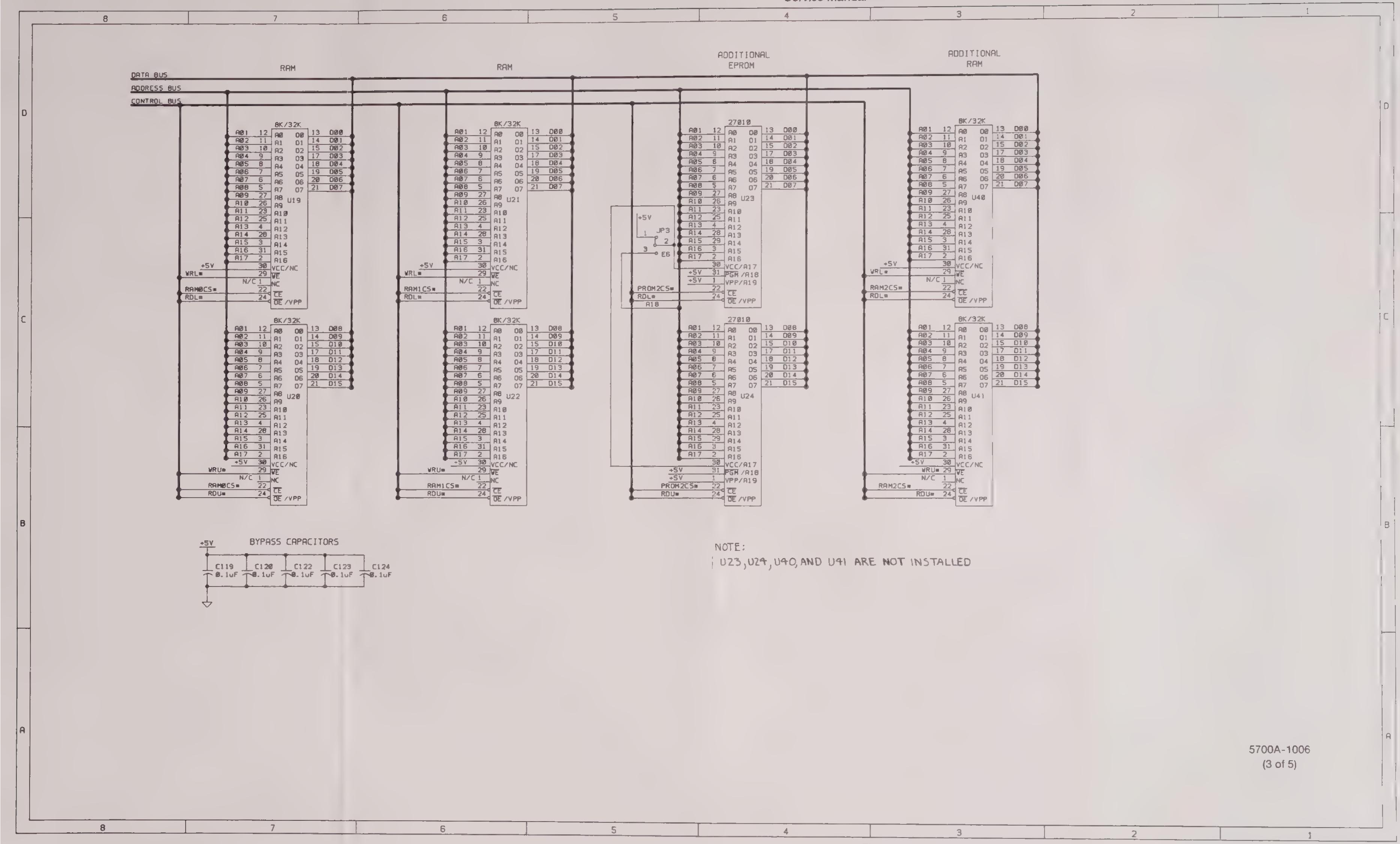
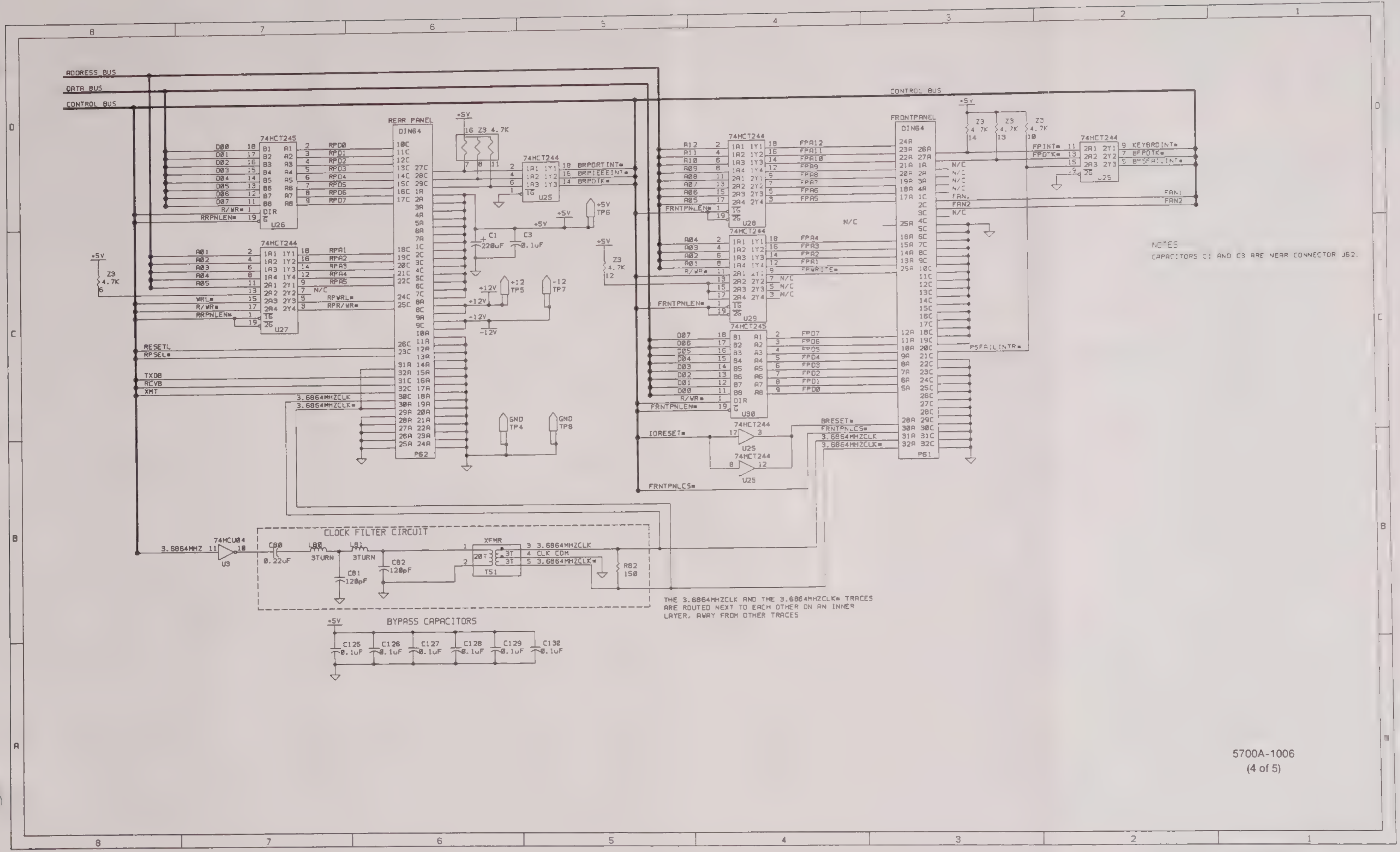


Figure 7-24. A20 CPU PCA (cont)



NOTE:
U23, U24, U40, AND U41 ARE NOT INSTALLED

Figure 7-24. A20 CPU PCA (cont)



NOTES
CAPACITORS C1 AND C3 ARE NEAR CONNECTOR J62.

THE 3.6864MHZCLK AND THE 3.6864MHZCLK= TRACES ARE ROUTED NEXT TO EACH OTHER ON AN INNER LAYER, AWAY FROM OTHER TRACES

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Figure 7-24. A20 CPU PCA (cont)

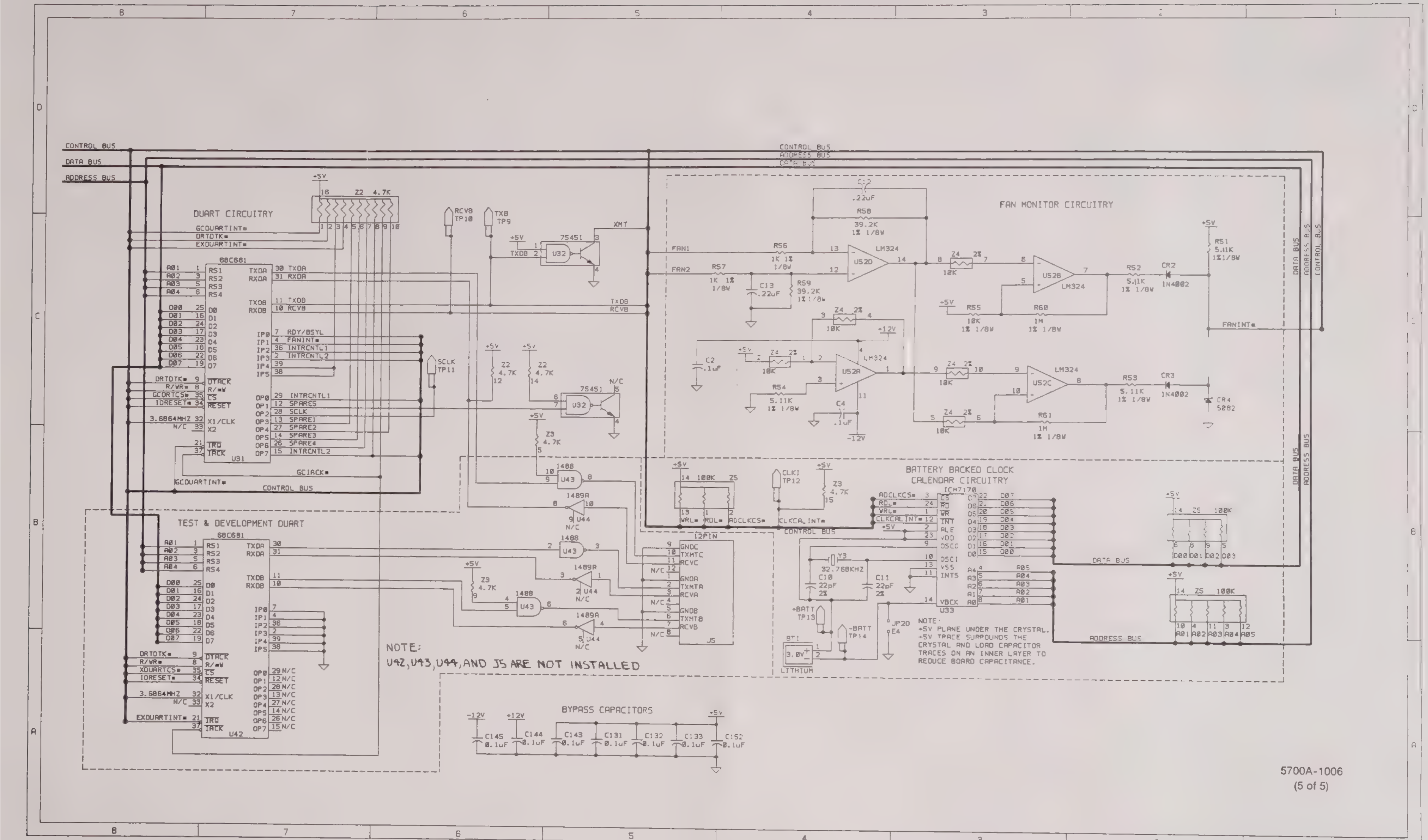


Figure 7-24. A20 CPU PCA (cont)

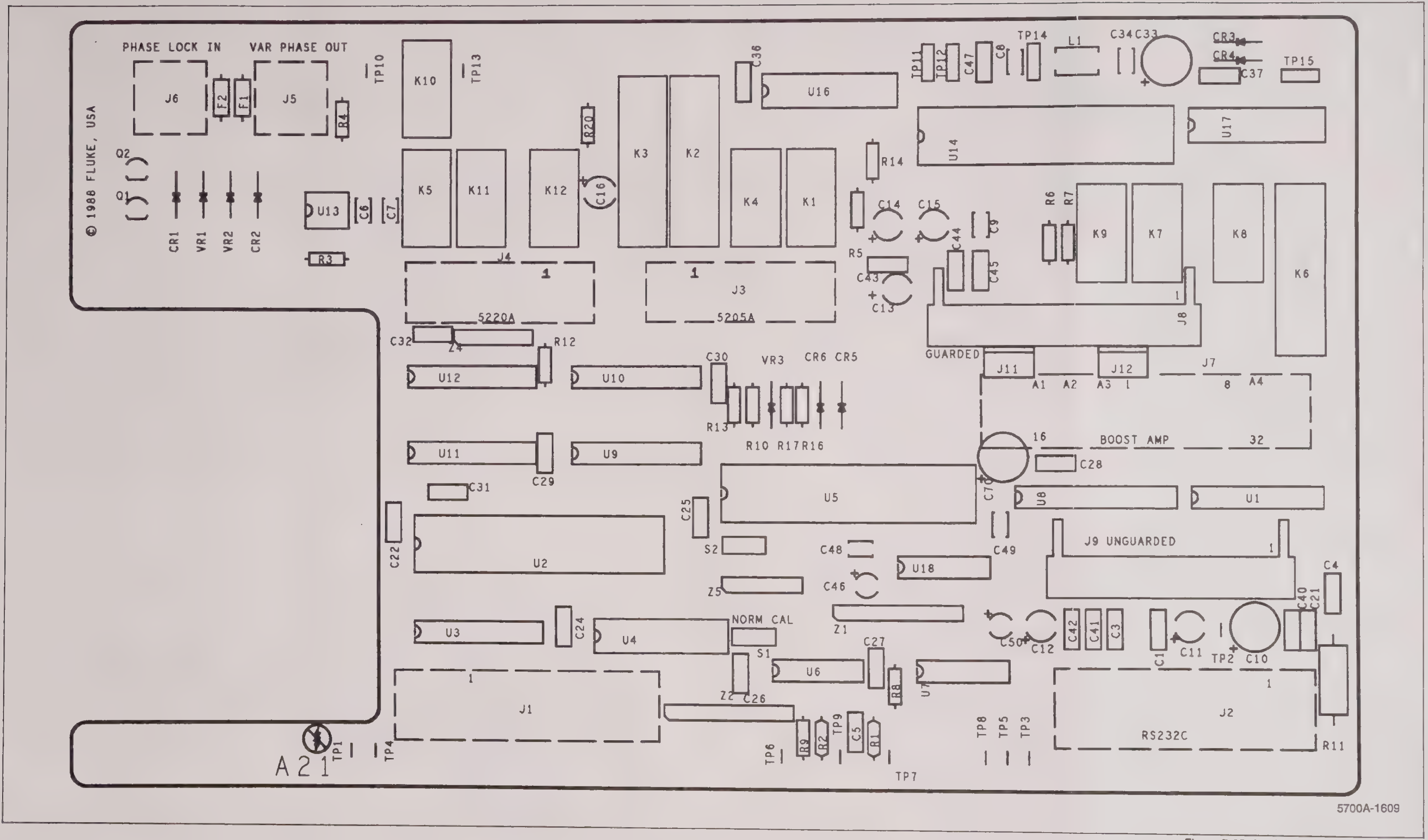
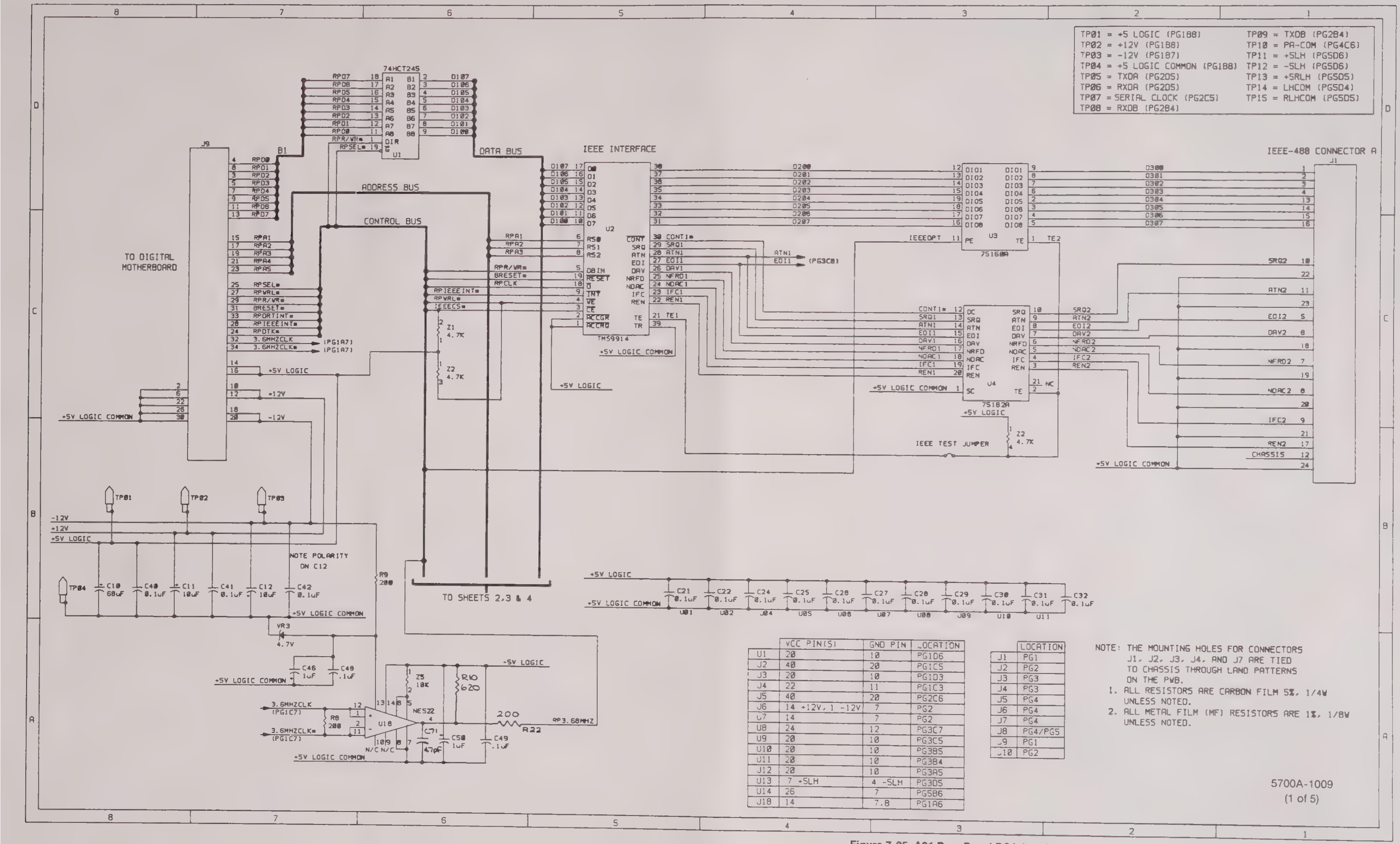


Figure 7-25. A21 Rear Panel PCA



TP01 = +5 LOGIC (PG1B8)
TP02 = +12V (PG1B8)
TP03 = -12V (PG1B7)
TP04 = +5 LOGIC COMMON (PG1B8)
TP05 = TXDA (PG2D5)
TP06 = RXDA (PG2D5)
TP07 = SERIAL CLOCK (PG2C5)
TP08 = RXDB (PG2B4)
TP09 = TXDB (PG2B4)
TP10 = PA-COM (PG4C6)
TP11 = +SLH (PG5D6)
TP12 = -SLH (PG5D6)
TP13 = +SRLH (PG5D5)
TP14 = LHCOM (PG5D4)
TP15 = RLHCOM (PG5D5)

	VCC PIN(S)	GND PIN	LOCATION
U1	20	10	PG1D6
J2	40	20	PG1C5
J3	20	10	PG1D3
J4	22	11	PG1C3
J5	40	20	PG2C6
J6	14 +12V, 1 -12V	7	PG2
U7	14	7	PG2
U8	24	12	PG3C7
U9	20	10	PG3C5
U10	20	10	PG3B5
U11	20	10	PG3B4
J12	20	10	PG3A5
U13	7 +SLH	4 -SLH	PG3D5
U14	26	7	PG5B6
J18	14	7,8	PG1A6

	LOCATION
J1	PG1
J2	PG2
J3	PG3
J4	PG3
J5	PG4
J6	PG4
J7	PG4
J8	PG4/PG5
J9	PG1
J10	PG2

NOTE: THE MOUNTING HOLES FOR CONNECTORS J1, J2, J3, J4, AND J7 ARE TIED TO CHASSIS THROUGH LAND PATTERNS ON THE PWB.

1. ALL RESISTORS ARE CARBON FILM 5%, 1/4W UNLESS NOTED.
2. ALL METAL FILM (MF) RESISTORS ARE 1%, 1/8W UNLESS NOTED.

5700A-1009
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Figure 7-25. A21 Rear Panel PCA (cont)

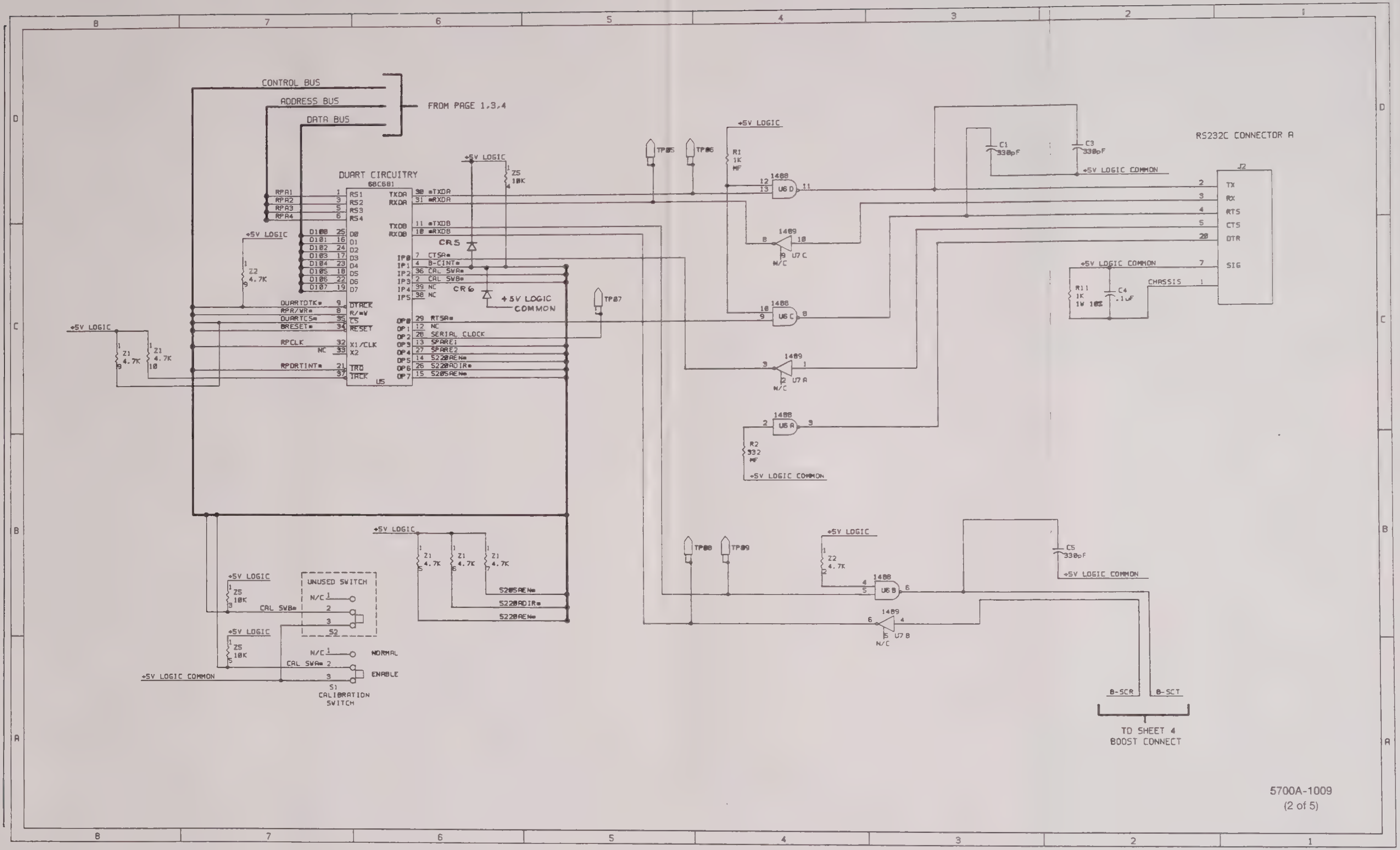


Figure 7-25. A21 Rear Panel PCA (cont)

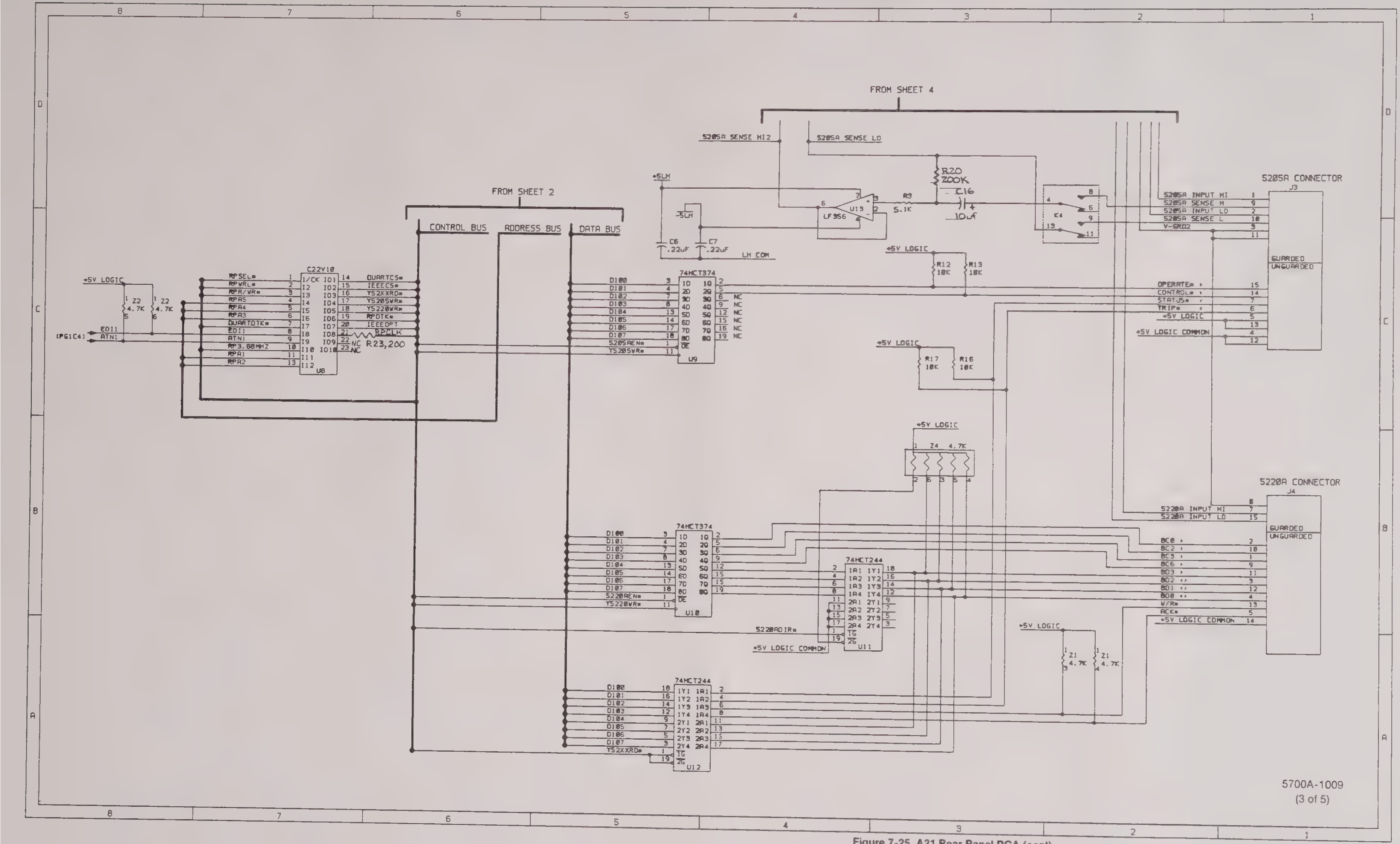


Figure 7-25. A21 Rear Panel PCA (cont)

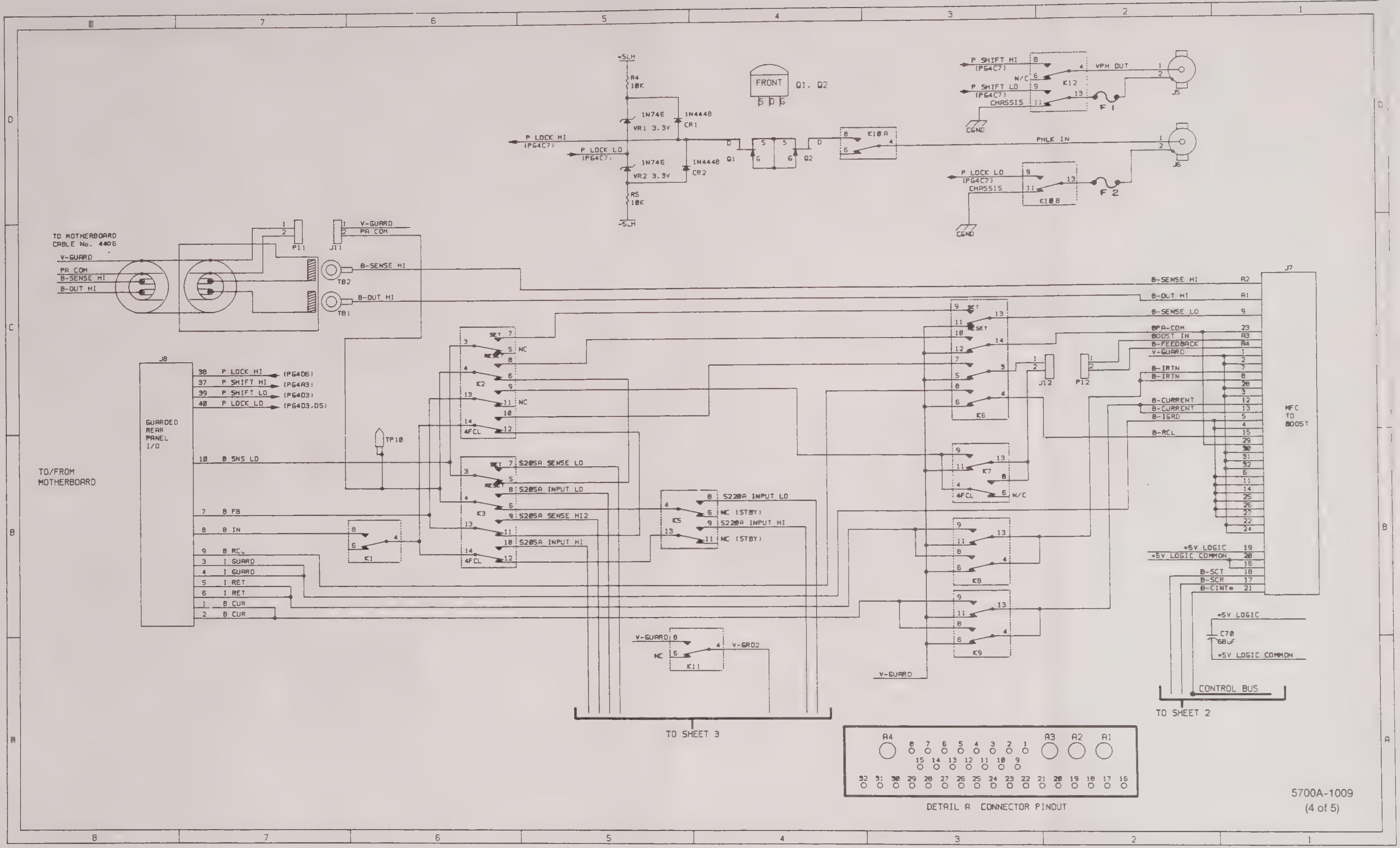
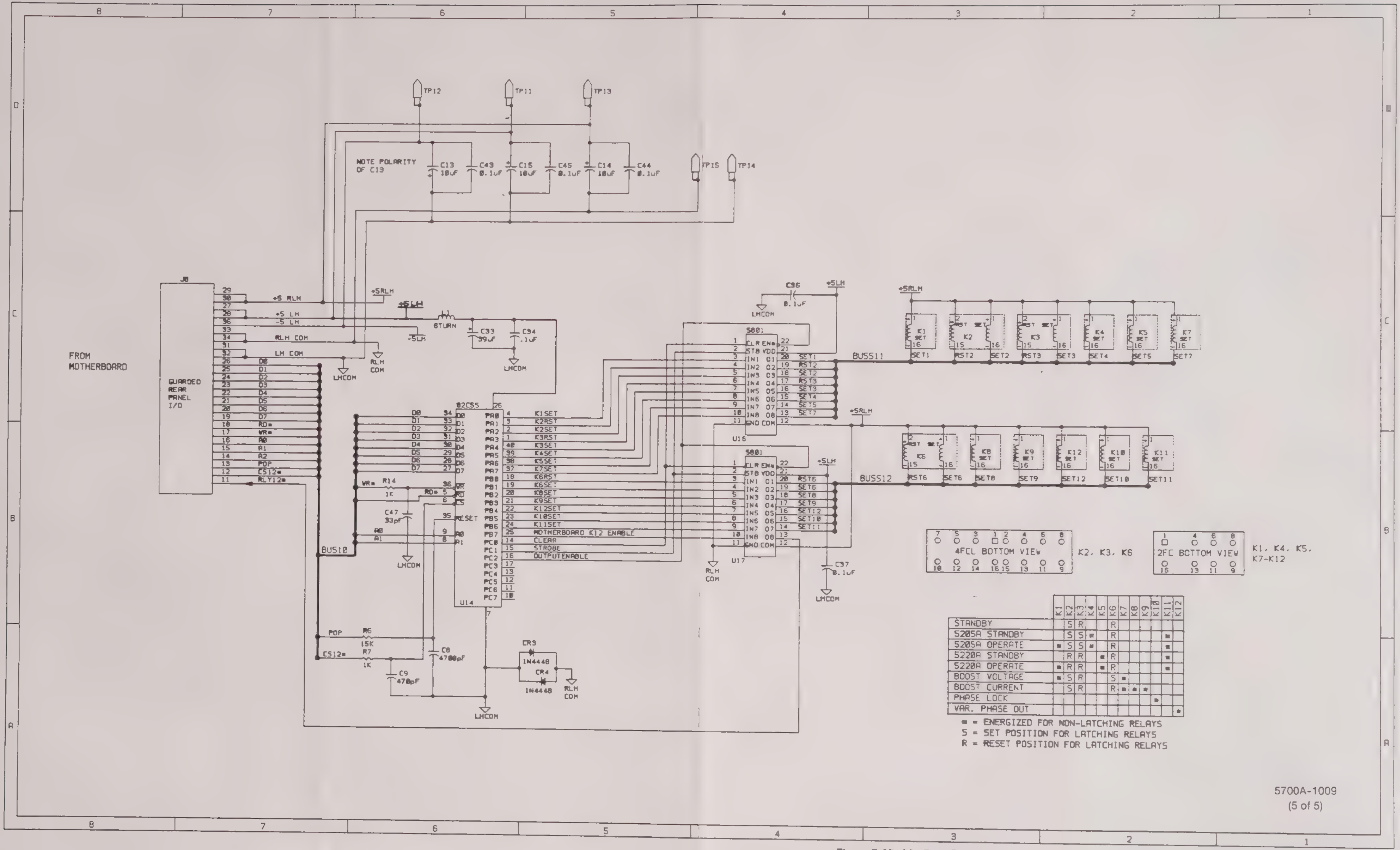


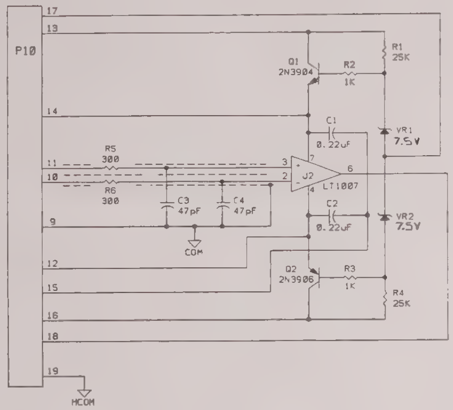
Figure 7-25. A21 Rear Panel PCA (cont)



	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12
STANDBY		S	R			R						
5205A STANDBY		S	S	■		R					■	
5205A OPERATE	■	S	S	■		R					■	
5220A STANDBY		R	R		■	R					■	
5220A OPERATE	■	R	R		■	R					■	
BOOST VOLTAGE	■	S	R			S	■					
BOOST CURRENT		S	R			R	■	■	■			
PHASE LOCK										■		
VAR. PHASE OUT												■

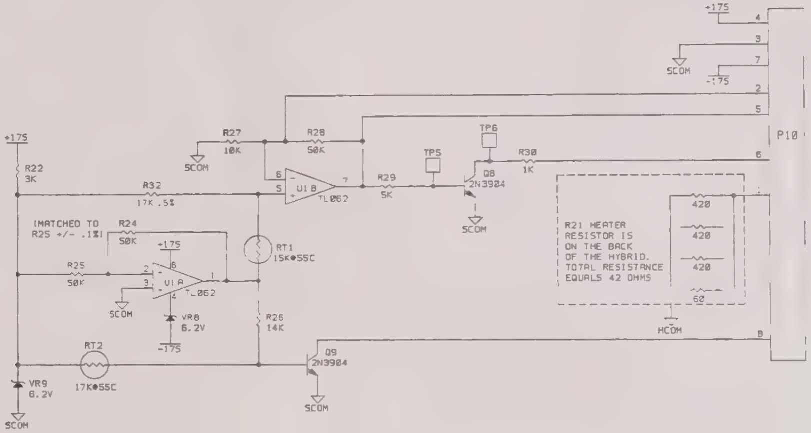
■ = ENERGIZED FOR NON-LATCHING RELAYS
S = SET POSITION FOR LATCHING RELAYS
R = RESET POSITION FOR LATCHING RELAYS

Figure 7-25. A21 Rear Panel PCA (cont)



NOTES: (UNLESS OTHERWISE SPECIFIED)

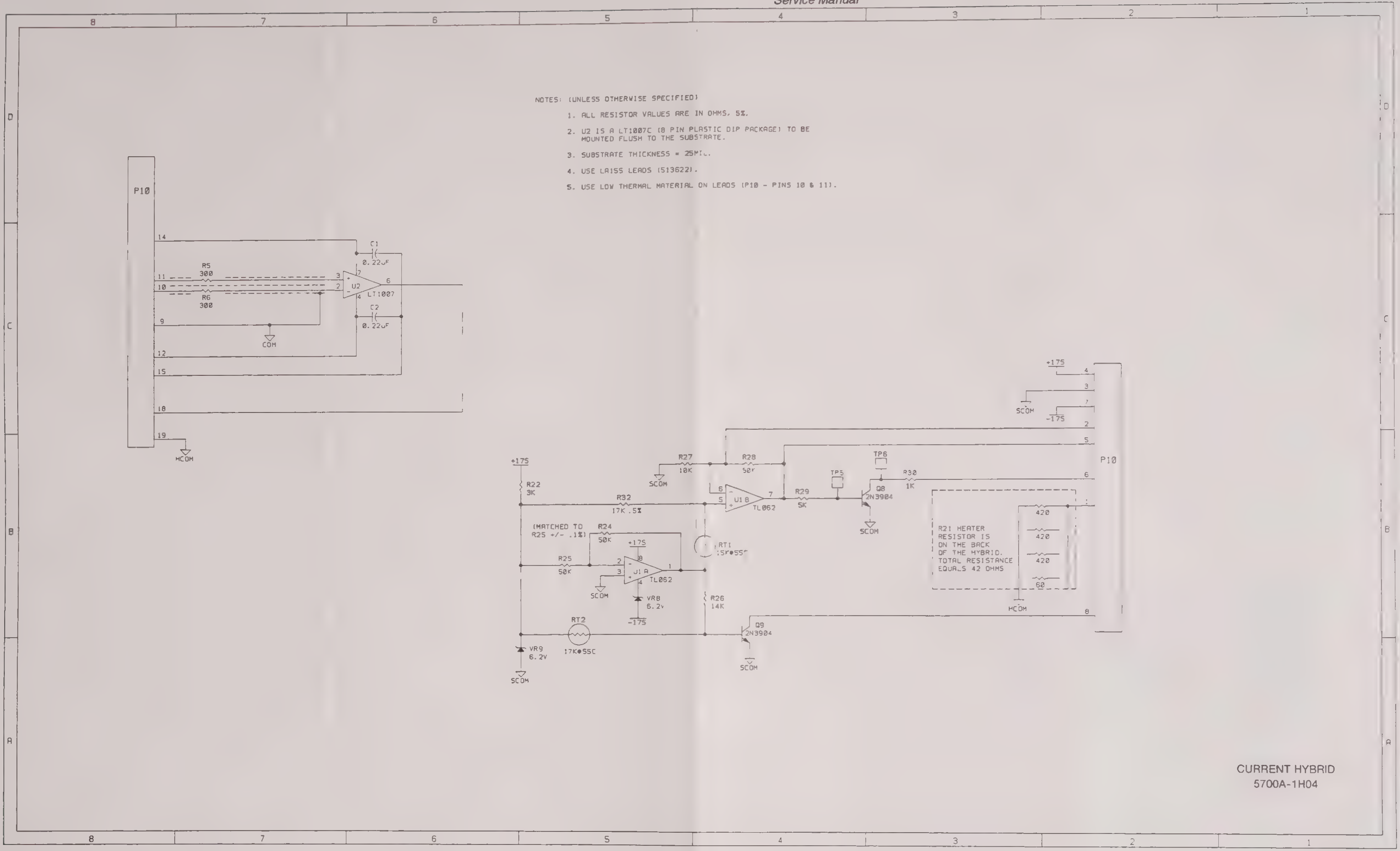
1. ALL RESISTOR VALUES ARE IN OHMS, 5%.
2. U2 IS A LT1007C (8 PIN PLASTIC DIP PACKAGE) TO BE MOUNTED FLUSH TO THE SUBSTRATE.
3. SUBSTRATE THICKNESS = 25MIL.
4. USE LAISS LEADS (513622).
5. USE LOW THERMAL MATERIAL ON LEADS (P10 - PINS 10 & 11).



HYBRID NAME	USED ON ASSEMBLY	REF DES	SCHEMATIC
2V DC HYBRID	Switch Matrix (A8)	HR1	1H03
CURRENT HYBRID	Current/Hi-Res Oscillator (A7)	HR2	1H04
REFERENCE HYBRID	DAC (A11)	HR5	1H42
DC AMP HYBRID	DAC (A11)	HR6	1H06
DC AMP HYBRID	High Voltage/High Current (A15)	HR7	1H06
DC AMP HYBRID	Power Amplifier (A16)	HR8	1H06
RES NET HYBRID	Oscillator Output (A13)	U5, U7, U11	1H54

2V DC HYBRID
5700A-1H03

Figure 7-26. Hybrids



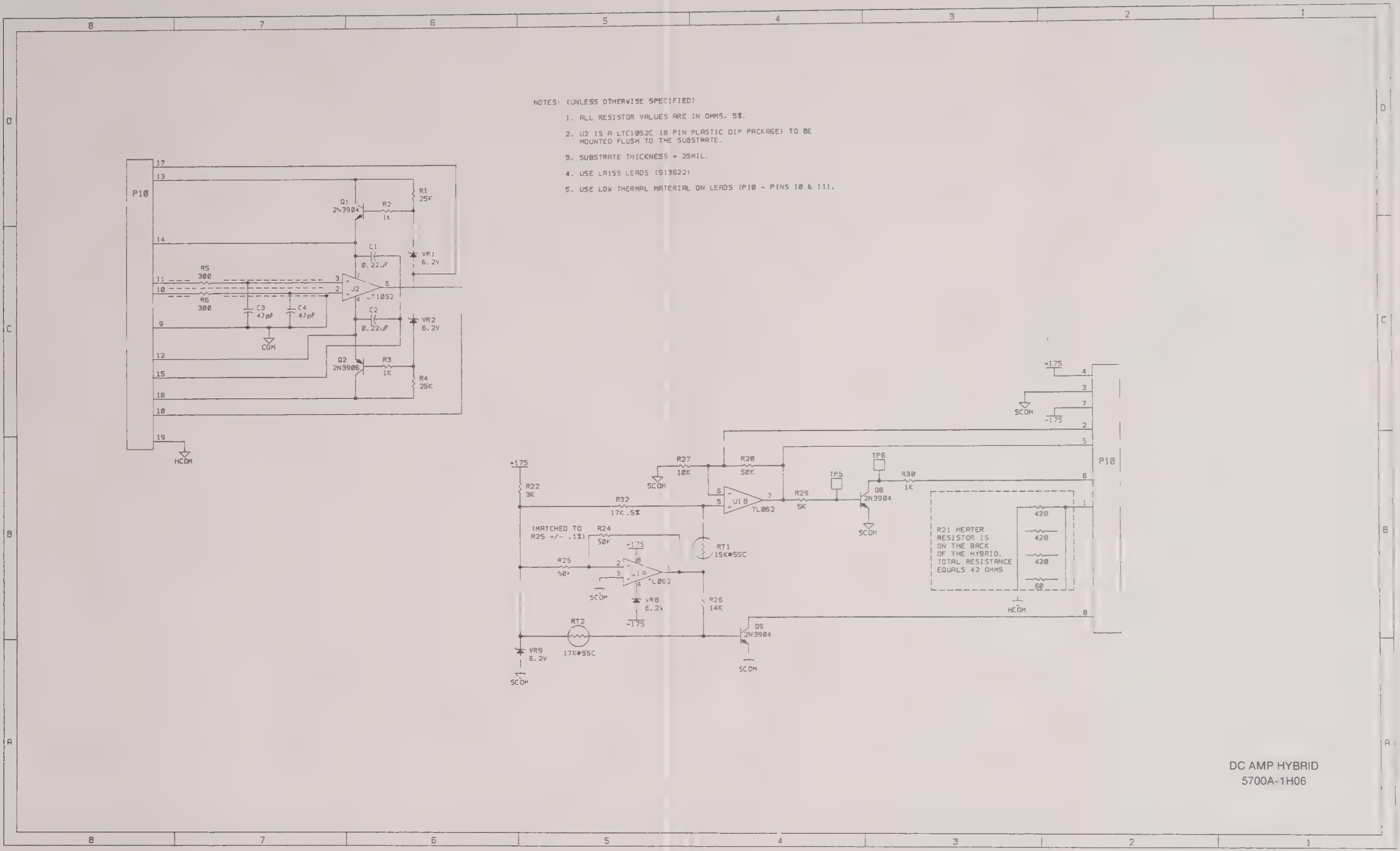
NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTOR VALUES ARE IN OHMS, 5%.
2. U2 IS A LT1007C (8 PIN PLASTIC DIP PACKAGE) TO BE MOUNTED FLUSH TO THE SUBSTRATE.
3. SUBSTRATE THICKNESS = 25MIL.
4. USE LA155 LEADS (513622).
5. USE LOW THERMAL MATERIAL ON LEADS (P10 - PINS 10 & 11).

R21 HEATER RESISTOR IS ON THE BACK OF THE HYBRID. TOTAL RESISTANCE EQUALS 42 OHMS

CURRENT HYBRID
5700A-1H04

Figure 7-26. Hybrids (cont)



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTOR VALUES ARE IN OHMS, 5%.
2. U2 IS A LTC1052C (8 PIN PLASTIC DIP PACKAGE) TO BE MOUNTED FLUSH TO THE SUBSTRATE.
3. SUBSTRATE THICKNESS = 25MIL.
4. USE LA155 LEADS (513622)
5. USE LOW THERMAL MATERIAL ON LEADS (P10 - PINS 10 & 11).

R21 HEATER RESISTOR IS ON THE BACK OF THE HYBRID. TOTAL RESISTANCE EQUALS 42 OHMS

(MATCHED TO R25 +/- .1%)

DC AMP HYBRID
5700A-1H06

Figure 7-26. Hybrids (cont)

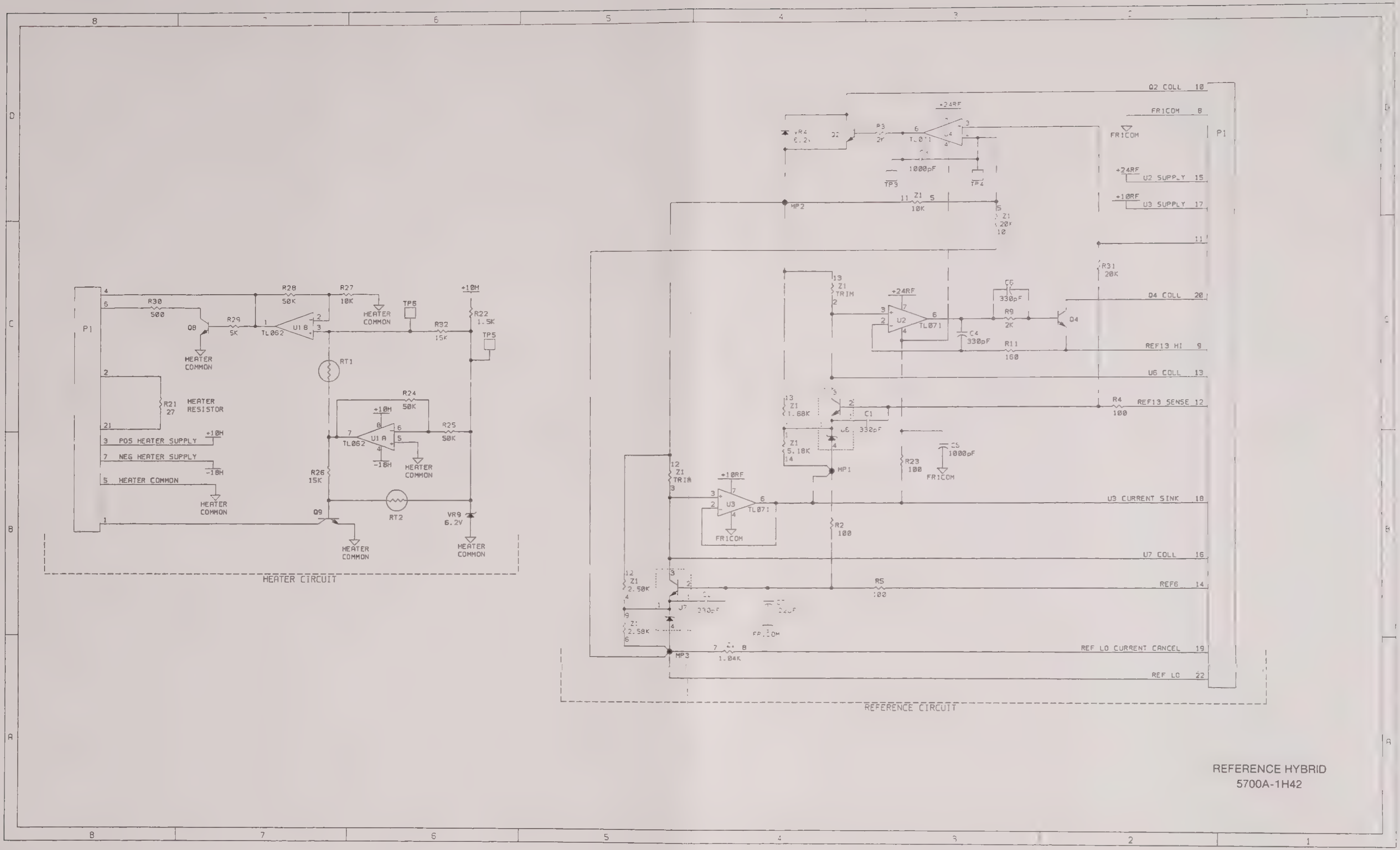


Figure 7-26. Hybrids (cont)

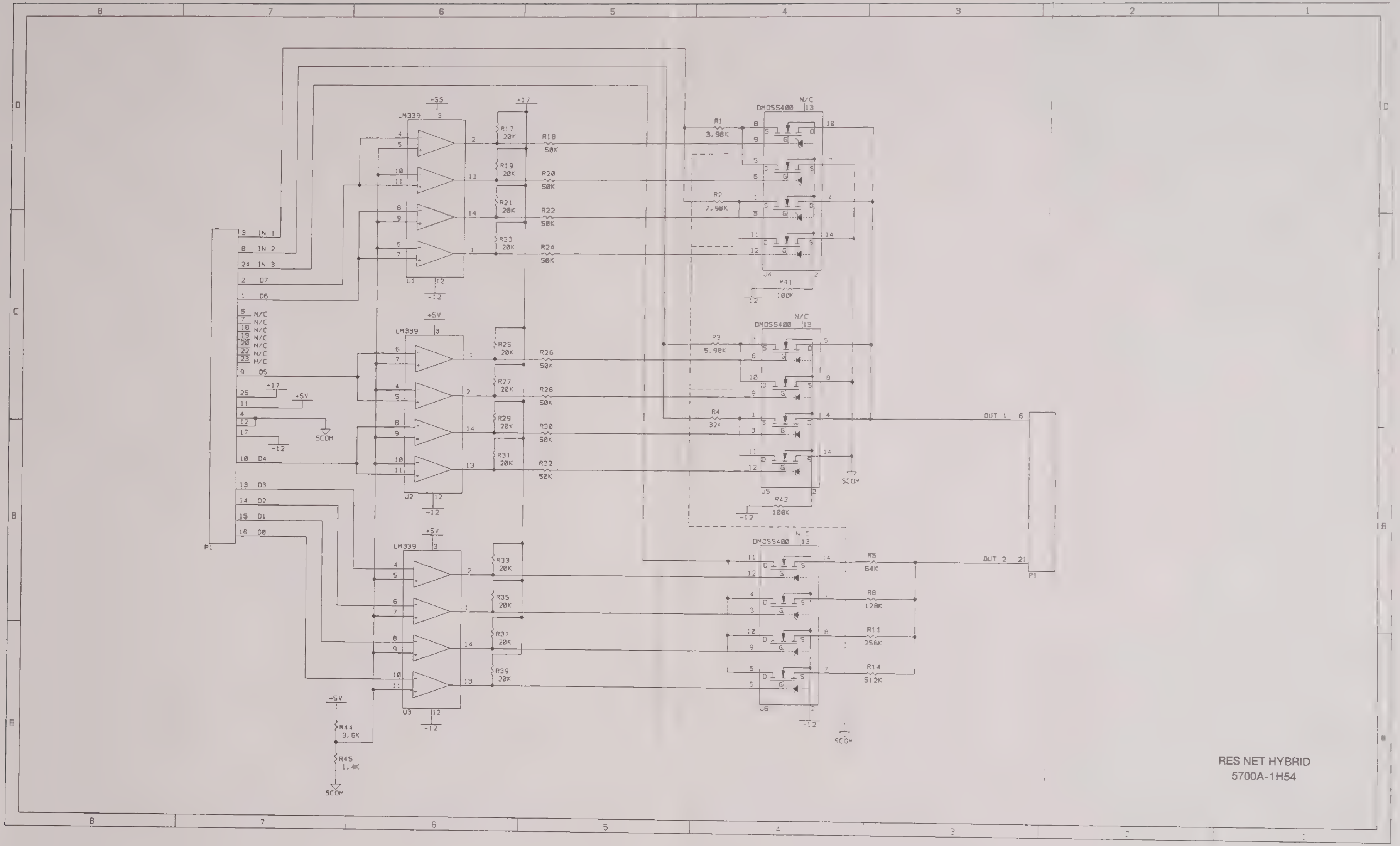


Figure 7-26. Hybrids (cont)

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